THE

NATURAL HISTORY

OF

ANIMALS, VEGETABLES,

MINERALS, &c.

THE
NATURAL HISTORY
OF
ANIMALS, VEGETABLES,
AND
MINERALS;
WITH
The THEORY of the EARTH in general.

Tranflated from the FRENCH

Of COUNT de BUFFON.

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THE

THEORY of the EARTH.

I HAVE myſelf, often obſerved with a kind of aſtoniſhment, as I have already ſaid, whole mountains, chains of rocks, enormous banks of quarries, all compoſed of ſhells and other wrecks of marine productions, which are met with therein in ſuch great quantities, that their volume far ſurpaſſes the matter which includes them.

I have ſeen cultivated fields in which all the ſtones were petrified petoncles, ſo that by ſhutting our eyes and taking them up by chance, we might bet we took up a petoncle: and the more we examine the earth, the more we ſhall be convinced that the number of theſe petrifications is infinite, and conclude, that it is impoſſible that all the animals which inhabited theſe ſhells exiſted at one and the ſame time.

I have even made an obſervation in ſearching after theſe ſhells, which may be of ſome utility, viz. that in all countries where we find a very great number of petrified ſhells in the fields and cultivable lands which are whole, well preſerved and totally apart

apart, we may be aſſured that the ſtone of theſe countries is *geliſſe*; theſe ſhells being only divided in ſuch great number by the action of the froſt which deſtroys the ſtone and ſuffers the petrified ſhells to ſubſiſt a longer time.

This immenſe quantity of marine foſſils found in ſo many places, proves that they have not been tranſported thither by the deluge; for we obſerve many thouſands of large rocks and quarries in every country compoſed of marble and lime ſtone, all filled with the vetebra of the ſea ſtar fiſh and other marine productions. Now if theſe ſhells, every where found, had been brought on the earth by a deluge, or inundation, the greateſt part would have remained on the ſurface of the earth, or at leaſt would not be interred very deep, nor ſhould we find them in the moſt ſolid marble at the depth of ſeven or eight hundred feet.

In all quarries theſe ſhells form a part of the internal part of the ſtone, and we ſee them ſometimes covered externally with ſtalactites, which as is known, are not ſuch ancient matters as the ſtone which contain ſhells: a ſecond proof that this did not happen by a deluge, is, that bones, horns, hoofs, &c. are found but very rarely, and perhaps not at all in marble and other hard ſtone, whereas, if it was the effect of a deluge, where all would have periſhed, we ſhould meet with the remains of land animals as well as thoſe of the ſea.

It is as we have obſerved, a very great ſuppoſition, to pretend that all the earth was diſſolved at the deluge, nor can we give any foundation to ſuch idea, but by ſuppoſing a ſecond miracle, which might have given the water the property of a univerſal diſſolvent, a miracle of which no mention is made in holy writ; beſides, what annihilates the ſuppoſition and renders it even contradictory, is, that all matters having been diſſolved in the water, ſhells have

have not been ſo, ſince we find them entire and well preſerved in all the maſſes which are ſaid to have been diſſolved; this evidently proves, that there never was ſuch diſſolution, and that the arrangement of the horizontal and parallel ſtrata was not made in an in-ſtant but by ſediments depoſited by degrees, and which have at laſt produced conſiderable eminences in proceſs of time: for it is evident to all who will take the trouble of obſerving, that the arrange-ment of all matters which compoſe the globe, is the work of the waters; the queſtion is therefore only to know, whether this arrangement was made at one time; now we have proved it could not be done all at once, ſince matters have not kept the order of ſpecific weight, and there has not been a general diſſolution of all matters, therefore this arrangement has been produced by the waters, or rather by the ſediments which they have depoſited in ſucceſſion of time; all other revolution, all other motion, and all other cauſe, would have produced a very different arrangement; beſides a particular accidental revolu-tion could not have produced a ſimilar effect on the whole globe, and if the particular and accidental re-volutions was the cauſe of the arrangement of the earth and ſtrata, we ſhould find ſtones and earths differently diſpoſed in different countries, whereas we find them diſpoſed every where alike by parallel, horizontal or equally inclined ſtrata. Let us ſee what the hiſtorians of the academy ſays on this ſubject. Anno. 1718, p. 3. &c.

" The very ancient and numerous remains of in-undations which muſt have been very extenſive, and the manner in which we are obliged to conceive mountains to be formed, ſufficiently proves, that for-merly great revolutions have happened to the ſurface of the earth. As far as we have been able to dig, we have ſcarcely ſeen any thing but ruins, wrecks and vaſt ſtones heaped up together, and which by a courſe

a courſe of ages are incorporated together, and united in one ſingle maſs as much as poſſible. If there is ſome kind of regular organization in the terreſtrial globe, it is deeper and conſequently will be always unknown to us, and all our reſearches will terminate in digging among the ruins of the external coat, and will ſtill furniſh ſufficient employment for our philoſophers.

M. de Juſſieu found in the environs of St. Chaumont, in Lyonnois, a great quantity of ſcaly or foliated ſtones, all the foliage of which bore on the ſuperfices the impreſſion of the end of a branch, a leaf, or the fragment of a leaf of ſome plant; the repreſentations of leaves were always exactly extended, as if the leaves had been ſpread on the ſtone with our hands, which proves that they had been brought thither by the water, which had kept them in that ſtate: they were in different ſituations, and ſome times two or three together.

It may well be ſuppoſed, that a leaf depoſited by the water in a ſoft mud, and afterwards covered with another like mud, imprints on the one the image of one of its two ſurfaces, and on the other the image of the other, ſo that theſe two lama of mud being hardened and petrified, took different impreſſions; but what we might think to have happened, is not ſo, the two lamas have the impreſſion of the ſame ſide of the leaf, the one in relief, the other hollow. M. de Juſſieu has obſerved in all theſe figured ſtones of St. Chaumont, this abſurd phenomena. We ſhall leave the explanation to him to paſs to what theſe ſorts of obſervations have more general and intereſting.

All the plants engraved in the ſtones of St. Chaumont are foreign plants; they are neither found in Lyonnois nor in the other parts of France, but only in the Eaſt Indies and the hot climates of Ame-

America: theſe plants are for the moſt part capillary plants, and often of the fern kind; their hard and compact coat has rendered them more proper to imprint and preſerve themſelves in the molds as much as the time permitted. Some leaves of Indian plants imprinted in the ſtones of Germany have appeared aſtoniſhing to M. Leibnitz, but here we find the ſame wonderful affair infinitely multiplied. There even ſeems in this reſpect to be a certain affectation of nature; in all the ſtones of St. Chaumont not a ſingle plant of the country has been found.

It is certain, by the ſhellfiſh in quarries and mountains, that this country, as well as many others, muſt have formerly been covered with the ſea, but how has the American or Eaſt Indian ſea reached thither?

To explain many phenomena, it may be ſuppoſed with ſufficient probability, that the ſea covered the whole terreſtrial globe, when there were no terreſtrial plants therein, and it is only ſince then, and ſince a part of the globe has been diſcovered, that great inundations have been made, which have conveyed the plants of one country into others very remote.

M. de Juſſieu thinks, that as the bed of the ſea always throws up earth, mud and ſand, which the rivers inceſſantly convey there; the ſea at firſt united between certain natural dykes, ſurmounted them and were diſperſed far off, and that the dykes were themſelves undermined by the waters and overthrown therein. In the earlieſt time of the formation of the earth nothing had taken a regular form; prodigious and ſudden revolutions might then have been made, of which we no longer have examples.

By ſome of theſe great revolutions the Indian ſea, whether oriental or accidental, will have been driven to Europe, and brought thither foreign plants

floating on its waters, which they tore up in their road, and depoſited gently in places where the water was only ſhallow, and might be ſoon evaporated.

ARTICLE IX.

On the inequalities of the earth.

THE inequalities which are on the ſurface of the earth, and which might be regarded as an imperfection to the figure of the globe, are at the ſame time a diſpoſition favourable and neceſſary to preſerve vegetation and life on the terreſtrial globe. To be aſſured of this, it is only requiſite to conceive for a moment what the earth would be, if it was even and regular. We ſhould ſee that inſtead of agreeable hills, from whence pure ſtreams of waters flow, to ſupport the verdure of the earth; inſtead of thoſe rich and flouriſhing countries, where plants and animals agreeably find ſubſiſtence; a diſmal ſea would cover the whole globe, and of all the earth's attributes there would only remain that of its being an obſcure and forſaken planet, at beſt only deſtined for the abode of fiſhes.

But independent of the moral neceſſity, which muſt ſeldom form a proof in philoſophy, there is one phyſical neceſſity why the earth is irregular on its ſurface, and that, becauſe by ſuppoſing it even perfectly regular in its origin, the motion of the waters, the ſubterraneous fires, the wind, and other exterior cauſes would have neceſſarily produced irregularities ſimilar to thoſe now ſeen.

The greateſt inequalities are the depths of the ocean, compared to the elevations of mountains; the depth is very different even at great diſtances from land; it is ſaid there are parts above a mile deep,

but

but there are few, and the moſt general profundities are from 60 to 150 fathom. The gulphs bordering on the coaſts are much leſs deep, and the ſtraits have generally the leaſt depths.

To ſound the depths of the ſea, a piece of lead of 30 or 40lb. is made uſe of faſtened to a ſmall cord, which is a very good method for common depths: but when we would ſound the great depths, we may err, and not find the bottom; becauſe, the cord being ſpecifically lighter than the water, after it has greatly divided it, the volume of the ſounding lead and that of the cord weighs no more than as much or leſs than a like volume of water. Hence the plumb deſcends no longer, and is removed in an oblique line, by preſerving always the ſame height; thus to ſound great depths an iron chain is required, or ſome other matter heavier than water. It is very probable that for want of conſidering this point, navigators tell us, that the ſea in a great number of places has no bottom.

In general, the profundities of the high ſeas, increaſe or diminiſh in a pretty uniform manner, and commonly the farther we go from ſhore the greater is the depth; yet this is not without exception, and there are places in the midſt of the ſea where ſhoals are found, as at Abrolhos in the Atlantic Ocean; there are others where there are banks of a very conſiderable extent, as the great bank, the bank called *le Bonneur* in our ocean, the banks, &c. of the Indian Ocean, &c.

So likewiſe along ſhore, the depths are very unequal, neverthelefs we may lay it down as a certain rule, that the depth of the ſea at the ſhore is always proportionate to the height of that ſhore; ſo that if the ſhore is very high, the depth will be very great, and on the contrary, if the ſhore is low, and the ground flat, the depth is very little, as in great rivers, where the high ſhores always announce a great depth.

It

It is likewiſe eaſier to meaſure the heights of mountains than the depths of the ſea, whether by means of practical geometry, or by the barometer. This inſtrument may give the height of a mountain very exactly, eſpecially in a country where its variation is not conſiderable, as at Peru and under the other parts of the equator; by one other of theſe means, the height of moſt eminences have been meaſured; for example, it has been found that the higheſt mountains of Switzerland are about 1600 fathom above the level of the ſea more than Canigou, which is one of the higheſt mountains of the Pyrenees, and it appears that they are the higheſt in Europe, ſince a great quantity of rivers flow from them, which carry their water into very remote and different ſeas, as the Po, which flows into the Adriatic, the Rhine which loſes itſelf in the ſands in Holland, the Rhone which falls into the Mediterranean, and the Danube which goes to the Black Sea. Theſe four rivers, whoſe mouths are ſo remote from each other, all derive a part of their waters from Mount Saint Godard and the neighbouring mountains, which proves that this part is the higheſt in all Europe.

The higheſt mountains in Aſia are Mount Taurus, Mount Imaus, Caucaſus, and the mountains of Japan; all theſe mountains are loftier than thoſe of Europe: the higheſt mountains in Africa, i. e. the great Atlas, and the mountains of the moon, are at leaſt as high as thoſe in Aſia, and the higheſt of all are in South America, particularly thoſe of Peru, which are more than 3000 fathom high, above the level of the ſea. In general the mountains between the tropics are loftier than thoſe of the temperate zones, and theſe more than thoſe of the frigid zones, ſo that the nearer we approach the equator, the greater are the inequalities of the earth: theſe inequalities, altho very conſiderable with reſpect to us, are nothing when conſidered with reſpect to the terreſtrial globe.

globe. Three thouſand fathom difference to 3000 miles diameter, is one fathom to a mile, or one foot to 2300 feet, which on a globe of 2½ feet diameter, does not make the 6th part of a line. Thus the earth, which appears to us croſſed and cut by the enormous height of the mountains, and by the frightful depth of the ſea, is nevertheleſs, relatively to its volume, only very ſlightly furrowed with irregularities, ſo very trifling, that they can cauſe no difference to the figure of the globe.

In continents the mountains are continued, and form chains. In iſlands they appear to be more interrupted and iſolated, and generally raiſed above the ſea, in form of a cone or pyramid, and are called *peaks*. The peak of Teneriffe is one of the higheſt mountains on the earth; it is near a mile and a half high perpendicular from the level of the ſea; the peak of St. George in one of the Acores; the peak of Adam in the iſland of Ceylon is alſo very lofty. All theſe peaks are compoſed of rocks, heaped one upon the other, and they vomit from their ſummits fire, cinders, bitumen, minerals, and ſtones. There are even iſlands which are preciſely only as tops of mountains, as the iſland of St. Helena, Aſcenſion, moſt of the Acôres, and Canaries; and we muſt remark, that in moſt of the iſlands, promontories, and other projecting lands in the ſea; the middle is always the higheſt, and they are generally ſeparated by chains of mountains, which divide them in their greateſt length, as mount Granſbain in Scotland, which extends from eaſt to weſt, and divides Great Britain into two parts; it is the ſame with the iſlands Sumatra, Lucon, Borneo, Celebes, Cuba, and St. Domingo, and alſo Italy, which is traverſed through its whole length by the Apenine mountains, &c.

The mountains as we find differ greatly in height, the hills are the loweſt of all; after them come the mountains of a moderate height, which are followed by

a third rank of mountains ſtill higher, which like the precediug, are generally loaded with trees and plants, but which furniſh no ſprings except at the bottom; in ſhort, the higheſt mountains are thoſe on which we find only ſand, ſtones, flints, and rocks, whoſe points often riſe above the clouds; it is exactly at the foot of theſe rocks that there are ſmall ſpaces, plains, hollows, and kinds of vallies, where the rain, ſnow and ice remain, and form ponds, moraſſes, and ſprings, from whence rivers derive their origin.

The form of mountains is alſo very different; ſome form chains whoſe height is very equal in a long extent of ſoil, others are cnt by very deep vallies, ſome are regular, and others appear at firſt ſight as irregular as poſſible; ſometimes in the middle of a valley or plain, we find a little iſolated mountain; and as there are mountains of different kinds, ſo there are alſo two ſorts of plains, the one in the low lands, the others in mountains. The firſt are generally divided by ſome large river; the others, though of a very conſiderable extent, are dry, and at fartheſt have only a ſmall rivulet. Theſe plains on mountains are often very high, and difficult of acceſs; they form countries above other countries, as in Auvergne, Savoy, and many other high places: The ſoil is firm, and produces much graſs, and odoriferous plants, which render theſe plains the beſt paſture in the world.

The ſummits of high mountains are compoſed of rocks of different heights, which reſemble from a diſtance the waves of the ſea. It is not on this obſervation alone we can rely, that the mountains have been formed by the waves, as I only relate it becauſe it accords with the reſt: but that which evidently proves that the ſea once covered and formed mountains, are the ſhells and other marine productions found throughout in ſuch great quantities, that it is not poſſible for them to have been tranſported by the

ſea

ſea into ſuch remote continents, and to ſuch conſiderable dephths; and what ſtill proves it are the horizontal and parallel ſtrata every where met with, and which can only have been formed by the waters: it is from the compoſition even of the hardeſt matters as ſtone and marble, by which we diſcover that the matters were reduced into powder before the formation of theſe ſtones and marble, and that they are precipitated to the bottom of the water in form of a ſediment: it is alſo proved by the exactneſs with which ſhells are moulded in theſe matters; it is the inſide of theſe ſhells, which are abſolutely filled with the matters in which they are encloſed; and in ſhort, what inconteſtably demonſtrates it, are the correſponding angles of mountains and hills, which no other cauſe than the currents of the ſea could have been able to form; the equality in the height of oppoſite hills, and beds of different matters, formed there at the ſame height, and the direction of mountains, whoſe chains extend in length in the ſame direction, as we ſee the waves of the ſea extend.

With reſpect to the depths at the ſurface of the earth, the greateſt, without contradiction, are the depths of the ſea, but as they do not preſent themſelves to our ſight, and as we can only judge of them by the plumb line, we only mean to ſpeak of the depths of dry land, ſuch as the deep vallies between mountains, the precipices between rocks, the abyſſes perceived from the tops of mountains, as the abyſs of mount Ararat, the precipices of the Alps, the vallies of the Pyrenees; theſe depths are a natural ſuite of the elevation of mountains; they receive the waters, and the earth which flow from the mountains, and the ſoil is generally very fertile and inhabited. As for the precipices which are between rocks, they are formed by the ſinking of rocks, the baſe of which ſometimes give way more on one ſide than the other, by the action of the air and froſt which ſplits and divides

vides them; and by the impetuous fall of torrents which opens paſſages, and carries along with them all that oppoſes their violence. But theſe abyſſes, that is to ſay, theſe vaſt and enormous precipices found at the ſummit of mountains, and to the bottom of which it is not poſſible ſometimes to deſcend, although they are above a mile or half a mile round, formed by the fire. Theſe abyſſes were formerly the funnels of volcanos, and all the matter which is there deficient, has been ejected by the action and exploſion of theſe fires, which are ſince extinguiſhed through a defect of combuſtible matter. The abyſs of mount Ararat, of which M. Tournefort gives a deſcription in his voyage to the Levant, is ſurrounded with bloek and burnt rocks, as one day the abyſſes of Etna, Veſuvius, and other volcanos will be, when they have conſumed all the combuſtible matters they include.

In Plots' natural hiſtory of Staffordſhire, a kind of gulph is ſpoken of, which has been ſounded to the depth of 2600 perpendicular feet, without meeting with any water; nay, the bottom was not found, as the rope was not long enough.

Great cavities and deep mines are generally in mountains, and they never deſcend, to a level with the plains; therefore by theſe cavities, we are only acquainted with the inſide of a mountain, and not at all with the internal part of the globe.

Beſides, theſe depths in fact are not very conſiderable. Ray aſſerts that the deepeſt mines are not above half a mile deep. The mine of Cotteberg which in the time of Agricola paſſed for the deepeſt of all known mines, was only 2500 feet perpendicular. It is evident there are holes in certain places, as that in Staffordſhire, or Pools Hole in Derbyſhire, the depth of which is perhaps greater, but all this is nothing in compariſon of the thickneſs of the globe.

If

If the kings of Egypt, inſtead of having erected pyramids, and raiſed ſuch ſumptuous monuments of their riches and vanity, had been at the ſame expence to ſound the earth, and make a deep excavation, matters perhaps might have been found, which would have amply recompenſed the trouble, labour, and expence, or at leaſt we ſhould have received lights on the matters of which the internal part of the globe is compoſed, which might be very uſeful, and which we at preſent have not.

But let us return to the mountains ; the higheſt are in the ſouthern countries, and the more we approach the equator, the more inequalities we find on the ſurface of the globe. This is eaſy to prove by a ſhort enumeration of the mountains and iſlands.

In America, the chain of the Cordilliers, the higheſt mountains of the earth, is exactly under the equator, and extends on the two ſides far beyond the circles which include the torrid zone.

In Africa, the higheſt mountains of the moon, and Monomotapa, the great and the little Atlas, are under the equator, or not far from it.

In Aſia, mount Caucaſus, the chain of which extends under different names, as far as the mountains of China, is nearer the equator than the poles.

In Europe the Pyrenees, the Alps, and mountains of Greece, which are only the ſame chain, are ſtill leſs diſtant from the equator than the poles.

Now theſe mountains which we have enumerated, are all higher, more conſiderable and extended in length and breadth than the mountains of the northern countries.

With reſpect to the direction of the chains of mountains, we ſhall find that the Alps taken in all their extent, form a chain which croſſes the whole continent from Spain to China : Theſe mountains begin at the ſea coaſt of Galicia, reach to the Pyrenees, croſs France by the Vivarais, and Auvergne,

divide Italy, extend into Germany, and beyond Dalmatia, as far as Macedonia, and from thence join with the mountains of Armenia, Caucasus, Taurus, Imaus, and extend as far as the Tartarian sea; so likewise mount Atlas traverses the whole continent of Africa, from west to east, from the kingdom of Fez to the Strait of the Red Sea, and the mountains of the moon have the same direction.

But in America, the direction is quite contrary, and the chains of the Cordilliers and other mountains extend from north to south more than from east to west.

What we here observe on the great eminences of the globe, may also be observed on the greatest depths of the sea. The vast and highest seas are nearer the equator than the poles, and there results from this observation, that the greatest inequalities of the globe is in the southern climate. These irregularities on the surface of the globe are the cause of an infinity of common and extraordinary effects: for example, among the rivers of India and the Ganges, there is a large peninsula, which is divided through its middle by a chain of high mountains which is called *the Gate*, and which extend from north to south, from the extremities of mount Caucasus to Cape Comorin; on one of the coasts is Malabar, and the other Coromandel, on the side of Malabar: between this chain of mountains and the sea the summer season lasts from September to April, during which the sky is serene and dry; on the other side of Coromandel the above season is their winter, and it rains every day there plentifully, and from the month of April to the month of September, is their summer; whereas it is winter in Malabar, insomuch that in many places, which are scarcely 20 miles distant, we may by crossing the mountain change seasons. Ir is said that the same thing is seen at Razalgat in Arabia, and at Jamaica, which

which is divided through its middle by a chain of mountains, whofe direction is from eaft to weft, and that the plantations to the fouth of thefe mountains feel the fummer heat, whereas thofe to the north endure the rigour of winter at one and the fame time. Peru, which is fituate under the line, and which extends about a thoufand miles to the fouth, is divided into three long and narrow parts, which the natives of Peru call *Lanos*, *Sieras*, and *Andes* The Lanos, which are the plains, extend along the coaft of the fouth fea; the Sieras are hills with fome vallies, and the Andes are thofe famous Cordilliers, the higheft mountains that are known. The Lanos differ ten miles more or lefs in breadth; in many places the Sierras are 20 miles broad, and the Andes as many more or lefs. The breadth is from eaft to weft, and the length from north to fouth. This part of the world is remarkable for the following particulars. 1ft. That in the Lanos, the wind conftantly blows from the fouth weft, which is contrary to what generally happens in the torrid zone. 2dly, It never rains nor thunders in the Lanos, although there is fometimes a little dew falls. 3dly, It almoft continually rains in the Andes. 4thly, In the Sierras, between the Lanos and the Andes, it rains from the month of September to the month of April.

It was for a long time known that the chains of the higheft mountains run from weft to eaft, after the difcovery of the new world. Confiderable ones have been formed which run from north to fouth, but no perfon before Mr. Bourguet difcovered the furprizing regularity of the ftructure of thofe great maffes: he found, after having croffed the Alps, 30 times in 14 different parts of it, twice over the Apenine mountains, and made divers tours in the environs of thefe mountains, and in mount Jura, that all mountains are formed nearly after the manner of works of a fortification. When the body of the mountain

mountain runs from eaſt to weſt, it forms prominences, which face as much as poſſible the north and ſouth ; this admirable irregularity is ſo ſtriking in vallies, that we ſeem to walk in a very regular covered way ; if, for example, we travel in a valley from north to ſouth, we perceive that the mountain which is on the right forms projections or angles which front the eaſt, and thoſe of the mountain on the left front the weſt, ſo that notwithſtanding the ſaillant angles of each ſide reciprocally anſwer the returning angles, which are always alternatively oppoſed to them. The angles which mountains form in great vallies are leſs acute, becauſe the direction is leſs ſteep, and as they are farther diſtant from each other ; and in plains they are not ſo perceptible as in the courſe of rivers, which generally take up their elbows ; the middle of them naturally anſwer the moſt ſtriking projections, or to the moſt advanced angles of mountains, to which the ground where the rivers flow, tend. It is aſtoniſhing ſo viſible a thing has not been obſerved, and when in a valley the inclination of one of the mountains which border it, is leſs ſteep than that of the other, the river takes its courſe much nearer the ſteepeſt mountain, and does not flow through its middle.

To theſe obſervations we may join other particular ones, which confirm them ; for example, the mountains of Switzerland are much more ſteep, and their direction much greater on the ſouthern ſide than on the north, and greater on the weſtern ſide than on the eaſtern. This may be perceived in the mountain of Gemmi, Briſe, and almoſt every other mountain. The higheſt in this country are thoſe which ſeperate Valicia and the Griſons from Savoy, Piedmont and Tirol. Theſe countries are a continuation of theſe mountains, the chain of which extends as far as the Mediterranean and continues even pretty far under the ſea. The mountains

tains of the Pyrenees are alſo only a continuation of that vaſt mountain, which begins in upper Valeſia, and whoſe branches extend very far to the weſt and ſouth, by always preſerving the ſame great height, whereas on the contrary, on the ſide of the north and of the eaſt, theſe mountains grow lower by degrees till they become plains. As we ſee by the large tract which the Rhine and Danube water before they reach their mouths, whereas the Rhine deſcends with rapidity towards the ſouth in the Mediterranean ſea. The ſame obſervation on the inclination of the mountains on the weſt and ſouth ſeas, then on the north and eaſt, is found to hold good in the mountains of England and Norway; but the part of the world where this is moſt evidently ſeen is at Peru and Chili; the long chain of the Cordilliers is cut very ſharply on the weſtern ſide, the length of the pacific ocean, whereas on the eaſtern ſide it lowers by degrees into large plains watered by the greateſt rivers of the world. (See Phil. Tranſ. Abr. vol. VI. part ii. p. 158.)

Mr. Bourguet, to whom we owe this great obſervation of the correſpondence of the angles of mountains with reaſon terms it, "the key of the theory of the earth;" nevertheleſs it appears to me, that if he had conceived all the importance of it, he would more ſucceſsfully have made uſe of it by connecting it with ſuitable facts, and would have given a more probable theory of the earth; whereas in this diſcourſe, he preſents only the ſcheme of a hypothetical ſyſtem, moſt of the conſequences of which are falſe or precarious. The theory we have given, turns on four principal facts, which cannot be doubted, after the proofs have been examined on which they are founded. The firſt is, that the earth is every where and to conſiderable depths, compoſed of parallel ſtrata, and matters which have formerly been in a ſtate of ſoftneſs: the ſecond is, that the ſea has for ſome time

time covered the earth ; the third, that the ſhaking and other motions of the waters produce inequalities at the bottom of the ſea ; and the fourth, that the mountains have taken their form and the correſpondent direction from the currents of the ſea.

We ſhall judge, after having read the proofs which the following articles contain, whether I was wrong to aſſert that theſe circumſtances ſolidly eſtbliſhed, alſo eſtabliſhes the truth of the theory of the earth. What I have ſaid in the text on the formation of mountains, has no need of a more ample explanation ; but as it might be objected that I do not give a reaſon for the formation of the peaks or points of mountains, no more than of ſome other particular circumſtances, I have thought it requiſite to add the obſervations and reflections which I have made on this ſubject.

I have endeavoured to form to myſelf a clear and general idea of the manner in which the different matters which compoſe the globe are arranged, and it appears to me, that they may be conſidered in a different manner from that in which they have hitherto been conſidered, and I have reduced them all into two general claſſes : the firſt is, of thoſe matters which we find placed in ſtrata or beds or banks horizontally or regularly inclined ; and the ſecond comprehends all matters formed in maſſes in perpendicularly and irregularly inclined veins. In the firſt claſs are comprehended ſands, argilaceous earth, granate, flints, coals, ſlates, &c. and marls, chalks, calcinable ſtone, &c. In the ſecond I rank metals, minerals, chriſtals, precious ſtones and ſmall flints : theſe two claſſes generally comprehend all known matters ; the firſt owe their origin to the ſediments carried away and depoſited by the ſea ; and we muſt diſtinguiſh thoſe which being aſſayed in the fire, calcine, and are reduced into lime, from thoſe which fuſe

fuſe and are reduced into glaſs, excepting thoſe, which the fire entirely conſumes by inflammation.

In the firſt claſs we diſtinguiſh two kinds of ſands, the one which I regard as the moſt abundant matter of the globe, which is vitrifiable, or rather which is only a compound of pieces of glaſs; the other whoſe quantity is much leſs calcinable, and muſt be looked upon as the fragments or powder of ſtone, and which differs from gravel by the ſize of the grains only. The vitrifiable ſand is in general depoſited by ſtrata like other matters, but, theſe ſtrata are often interrupted by maſſes of gres, flint and ſometimes theſe matters are alſo in banks and large beds.

By examining this ſand and theſe vitrifiable matters, we find only a few ſea ſhells there, and thoſe not placed in beds; they are only diſperſed therein, and as if thrown there by chance. For example, I have never ſeen them in grés; that ſtone which is very plenty in certain places, is only compoſed of ſandy parts, which are reunited, and are only met with in ſandy ſoil and generally the quarries of grés are in peaked hills and in divided eminences. We may attack theſe quarries in all directions, and if there are beds therein, they are much farther from each other than in quarries of calcinable ſtone or marble. In the body of the quarry blocks of gres are cut of all dimenſions and in all directions according as is required, and although the gres is difficult to work, it nevertheleſs has but a degree of hardneſs which is to reſiſt powerful ſtrokes without ſplitting: for friction by degrees reduces it eaſily into ſand, excepting certain blackiſh pieces found therein, and which are ſo very hard, that the beſt files cannot touch them. Rock is vitrifiable as gres and of the ſame nature, only it is harder and the parts more connected. There are alſo many hard pieces like thoſe we ſpeak of, as may eaſily be remarked on the ſummits of high mountains, which for the moſt part are of that kind of rock we cannot walk long with-

out

out perceiving that it cuts and tears our ſhoes. This rocky ſtone, which is found at the top of high mountains, and which I look upon as a kind of granate, contain a great quantity of talky leafs and are of different hardneſs to the point of not being worked but by an infinite deal of trouble and labour.

I have narrowly examined the nature of theſe ſharp pieces which are found in gres and rock, and have diſcovered it to be a metallic matter melted and calcined by a very violent fire, and which perfectly reſembles certain matter thrown out by the volcanos of which I ſaw a great quantity when I was in Italy, where the people called them *Schiarri*. They are very heavy, black maſſes, on which fire, water, nor the file, will make any impreſſion, and the matter of which is different from that of the Lava; for this is a kind of glaſs, whereas the other appears to be more metallic than vitreous. The ſharp pieces of gres and rock reſemble greatly this firſt matter, which ſeems ſtill to prove that all theſe matters have been formerly liquified by fire.

We ſometimes ſee in certain places, on the upper parts of mountains, a prodigious quantity of blocks of this rock mixed with talky leaves; their poſition is ſo irregular, that they appear to have been thrown there by chance, and it might be thought they had fallen from ſome neighbouring height, if the places where they are found were not raiſed above the other parts. But their vitrifiable and their angular and ſquare figure like that of the rocks of gres, diſcovers them to be of one common origin. Thus in the great beds of vitrifiable ſand, blocks of gres and rock are formed, whoſe figure and ſituation do not exactly follow the horizontal poſition of theſe ſtrata, by degrees the rain carried away from the ſummit of the hills and mountains the ſand which at firſt covered them, and they began to furrow and cut thoſe hills into the ſpaces which are found between the nucleus of gres,

as

as the hills of Fontaiubleau are cut. Each hilly point anſwers to a quarry of gres, and each interval has been excavated and looſened by the water, which has cauſed the ſand to flow into the plain, ſo likewiſe the higheſt mountains, whoſe ſummits are compoſed of rock and terminated by theſe angular blocks, have formerly been covered by many ſtrata of vitrifiable ſand in which theſe blocks have been formed, and the rain having ſwept away the ſand which covered them, they remained on the top of the mountains in the poſition they were formed in. Theſe blocks generally preſent points; they increaſe in ſize in proportion as they deſcend, one block often joins another by the baſe; this ſecond, a third, and ſo on, leaving irregular intervals between them, and as in time the rain waſhed away all the ſand which covered theſe different parts on the top of the high mountains, they remained naked, forming larger or leſſer points, and this is the origin of the peaks or horns of mountains.

For ſuppoſing, as it is eaſy to prove by the marine productions we find there, that the chain of the Alps was formerly covered by the ſea, and that above this chain there was a great thickneſs of vitrifiable ſand, which the ſea had carried and depoſited there, in the ſame manner and by the ſame cauſes as it has depoſited and carried away into the lower places a great quantity of ſhells, and by conſidering this external ſtrata of vitrifiable ſand as firſt depoſited level and forming a flat country of ſand on the top of the Alps, when they were covered by the ſea. There will be formed in this depth of ſand, rocks, gres, flint, and all matters which take their origin and figure in ſand by a mechaniſm nearly ſimilar to that of the chriſtalliſation of ſalts. Theſe once formed will have ſupported the points where they are found, and the rain will, by degrees,

 have

have loosened all the intermediate sand, as well as that which surrounded them. The torrents and rivulets by rushing precipitately from the top of these mountains, will have washed away these sands into the valleys and plains, and will have conveyed a part as far as the sea. In this manner the summits of mountains have been left bare, and the naked rocks, &c. have appeared throughout their whole height. These are what we at present call the peaks of mountains, and what has formed all those pointed eminences we see in so many places. This is also the origin of those high and isolated rocks seen in China and other parts, as in Ireland where they are called the Devil's Stones, and whose formation as well as that of the peaks of mountains, had always appeared difficult to explain; nevertheless the explanation which I give is so natural, that it directly presented itself to the mind of those who have seen these rocks, and I must here quote what Pere de Tartre says in his edifying letters, "From Yanchu-in-Yew we came to Ho-tcheou, and on the road met with something particular: i. e. rocks of an extraordinary height, of the shape of a large square tower, and situate in the midst of vast plains; it is not known how they came there, if they were not formerly mountains, from which the rain having washed away the earth which surrounded them, have left them in this situation. What strengthens the conjecture is, that we saw some which towards the base are still covered with earth to a certain height.

The summit of the highest mountains is therefore composed of rocks, many kinds of granate, gres and other hard and vitrifiable matters, and this often as deep as two or three fathom; after which we often meet with quarries of marble or hard stone filled with shells, and whose matter is calcinable, as may be remarked at Great Chartreuse in Dauphiny

phiny and on mount Cenis, where the ſtone and marble which contain ſhells, are ſome hundred fathom below the ſummits, points and peaks of the higheſt mountains, although theſe ſtones filled with ſhells, are themſelves at more than a thouſand fathom above the level of the ſea. Thus mountains whereon we ſee points or peaks, are generally vitrifiable rock, and thoſe whoſe ſummits are flat, moſtly contain marble and hard ſtones filled with marine productions. It is the ſame with gres or rock, they are moſtly interſected with points, eminences, earth and cavities: depths and ſmall intermediate valleys, on the contrary, thoſe which are compoſed of calcinable ſtone are nearly equal in height. They are only interrupted by greater and more regular valleys, whoſe angles are correſpondent. At laſt, they are crowned with rocks whoſe poſition is regular and level.

Whatever difference which may appear to us at firſt between theſe two forms of mountains, they nevertheleſs both proceed from the ſame cauſe, as we have already obſerved; only it muſt be remarked, that theſe calcinable ſtones have not undergone any alteration nor change, ſince the formation of the horizontal ſtrata, whereas thoſe of vitrifiable ſand, have been changed and interrupted by the poſterior production of rocks and angular blocks formed within this ſand. Theſe two kinds of mountains have cracks which are almoſt always perpendicular in thoſe of calcinable ſtones, and which appear to be a little more irregular in thoſe of rock and gres. It is in theſe cracks metals, minerals, chriſtals and ſulphurs, and all matters of the ſecond claſs are found, and it is below theſe cracks that the water collects to penetrate farther and form veins of water found below the ſurface of the earth.

PROOFS

Proofs *of the* THEORY *of the* EARTH.

ARTICLE X.

Of Rivers.

WE have before ſaid, that generally ſpeaking, the greateſt mountains are in the midſt of iſlands and the projections in the ſea. That in the old continent the greateſt chains of mountains are directed from weſt to eaſt, and that thoſe which incline towards the north or ſouth, are only branches of theſe principal chains; we ſhall find likewiſe, that the greateſt rivers are directed as the greateſt mountains, and that there are but few which follow the direction of the branches of thoſe mountains. To be aſſured of this, we have only to look on a globe, and trace the old continent from Spain to China. We ſhall find by beginning at Spain, the Vigo, Douro, Tagos, and Guadiana run from eaſt to weſt and the Ebro from weſt to eaſt, and that there is not one remarkable river whoſe courſe is directed from ſouth to north or from north to ſouth, although Spain is entirely ſurrounded by the ſea on the weſt ſide, and almoſt ſo on the north. This obſervation on the direction of rivers in Spain, not only proves that the mountains in this country are directed from weſt to eaſt, but alſo that the ſouthern land which borders on the ſtraits, and that of the ſtraits itſelf, is higher than the coaſts of Portugal; and ſo likewiſe on the northern coaſt, that the mountains of Galicia, the Aſturias, &c. are only a continuation of the Pyrenees, and that it is this elevation of the earth, as well north as ſouth, which does not permit the rivers to run into the ſea that way.

It will alſo be ſeen, by looking on the map of France, that there is only the Rhine which is directed

rected from the north to the ſouth, and nearly the middle of its courſe from the mountains to Lyon, it is directed from the eaſt towards the weſt; but that on the contrary, all the other great rivers, as the Loir, the Charent, the Garonne and even the Seine, have a direction from eaſt to weſt.

It will be likewiſe perceived, that in Germany there is only the Rhine which like the Rhone, ſhapes the greateſt part of its courſe from ſouth to north, but that the others, as the Danube, the Drave, and all the great rivers which fall into theſe floods flow from the weſt to eaſt into the black ſea.

It will be perceived that this black ſea, which muſt rather be conſidered as a great lake than a ſea, has almoſt three times more extent from eaſt to weſt than from ſouth to north, and that conſequently its poſitions is ſimilar to the direction of rivers in general; that it is the ſame with the Mediterranean ſea, whoſe length from eaſt to weſt is about ſix times greater than its mediate breadth, taken from north to ſouth.

In fact, the Caſpian ſea, according to the chart which has been drawn by the order of Czar Peter, has more extent from the ſouth to the north, than from eaſt to weſt; whereas in the ancient maps it was almoſt found broader from eaſt to weſt than from ſouth to north; but if we conſider that the lake Aral may be regarded as having been a part of the Caſpian ſea, from which it is ſeperated only by plains of ſand, we ſhall find alſo that the length from the weſtern coaſt of the Caſpian ſea as far as the oriental border of Lake Aral, is greater than the length from the ſouthern coaſt to the northern coaſt of the ſame ſea.

So likewiſe we ſhall find, that the Euphrates and the Perſian gulph, are directed from eaſt to weſt, and that almoſt all the rivers in China run from weſt to eaſt; it is the ſame with all the rivers in Africa beyond Barbary; they all flow from eaſt to weſt, and from

from weſt to eaſt, and there are only the rivers of Barbary and the Nile, which flow from ſouth to north. In fact, there are great rivers in Aſia, which partly run from north to ſouth, as the Volga, the Don, &c. but by taking the whole length of their courſe, we ſhall find that they only turn from the ſouth, to run into the Black and Caſpian Sea, which may be called only inland lakes.

It may therefore in general be ſaid, that in Europe, Aſia, and Africa, the rivers, and other Mediterranean waters, extend more from the eaſt to the weſt than from north to ſouth, which proceeds from the chains of mountains being for the moſt part ſo directed, and that in other reſpects the whole continent of Europe and Aſia is broader in this direction than the other; for there are two modes of conceiving this direction. In a long and narrow continent like South America, in which there is only one principal chain of mountains, that is to ſay, from eaſt to weſt, or from weſt to eaſt; in fact, it is in this direction all the rivers of America flow, becauſe, excepting the Cordillieros, there are no very extenſive chains of mountains, and none whoſe directions are parallel to them. In the old as well as the new Continent, moſt of the waters have their greateſt extent from weſt to eaſt, and moſt of the rivers flow in this direction, which is cauſed by another reaſon, i. e. that there are many long chains of mountains parallel to each other, whoſe direction is from weſt to eaſt, and becauſe the rivers and other ſtreams are obliged to follow the intervals which divide theſe chains of mountains, conſequently one ſingle chain of mountains, directed from north to ſouth, will produce rivers, whoſe direction will be the ſame as that of thoſe which iſſued from many chains of mountains, whoſe common direction is from eaſt to weſt, and it is for this particular reaſon, that the rivers of America have this direction in common with thoſe of Europe, Africa, and Aſia.

In

In general, rivers run through valleys, or rather the loweſt part of the ground betwixt two oppoſite hills or mountains; if the two hills on each ſide of a river have each nearly an equal inclination, the river will nearly be in the middle of the intermediate valley. Let this valley be broad or narrow, if the inclination of the hills or high lands on each ſide of the river, is equal, the river will be in the middle of the valley: on the contrary, if one of the hills has a more ſteep inclination than the oppoſite hill, the river will not be in the middle of the valley, but much nearer the hill whoſe inclination is greateſt, and this is the reaſon why the river is alſo nearer it. In all places where there are mountains and very ſteep hills on one ſide of a river, and on the other high land with gentle aclivities, we ſhall always find that the river flows at the foot of theſe ſteep hills, and that they follow them throughout all their directions, without quitting them, until they meet other hills on the oppoſite ſide, whoſe inclination is conſiderable enough to admit the loweſt part of the ground to be farther diſtant from the ſteep hill than it was before. It generally happens by length of time, the inclination of the ſteepeſt hill diminiſhes, becauſe the rain waſhes away the earth in a greater quantity, and with more violence on a ſteep inclination than on a gentle one. The river then is conſtrained to change its bed, and ſeek the loweſt part of the valley; to this may be added, that as all rivers enlarge from time to time, they tranſport and depoſit mud and dirt in different places, and that often ſands accumulate in their beds, and cauſe a reflux of the water, which changes its direction. It is very common to meet with a great number of the old beds of the river in plains, particularly if it is ſubject to frequent inundations, and carries off much ſand and dirt.

In plains and large vallies where there are great floods, the bed is generally the loweſt part of the valley,

valley, but the ſurface of the water is very often higher than the ground adjacent to the borders of the river. Let us ſuppoſe, for example, that the ſhores and water are level, and that the water ſoon after began to overflow, the plain will preſently be inundated to a conſiderable breadth, and it will be obſerved that the borders will be inundated the laſt, which proves that they are higher than the reſt of the ground, ſo that on each ſide the river, from the banks to a certain part of the plain, there is an inſenſible inclination, a kind of inclination which cauſes the ſurface of the water to be higher than the plain, particularly where the river is full. This elevation on the banks of rivers proceeds from the depoſit of the mud of inundations: the water is commonly very muddy in the great ſwellings of rivers; when it begins to overflow, it flows very gently over the banks, and depoſits the mud contained therein, and as we may ſay, depurates itſelf, in proportion as it runs farther into the plain; ſo alſo all the ſoil which the current of the river does not carry along, is depoſited on the banks, which raiſes them by degrees above the reſt of the plain.

Rivers, as is well known, are always broadeſt at their mouths; in proportion as we advance in the country, and are more remote from the ſea their breadth diminiſhes; but what is more remarkable, and poſſibly leſs known, is, that in the inland parts, they flow in a direct line, but in proportion as they approach their mouths, the ſinuoſities of their courſe increaſes. I have been informed by M. Fabry, a ſenſible traveller, who went ſeveral times by land into the weſtern part of North America, that travellers and even the ſavages themſelves are ſeldom deceived on the diſtance they are from the ſea; they follow the bank of a large river, and when the direction of the river is ſtrait for 15 or 20 miles, they judge themſelves to be at a great diſtance from the ſea; but on the contrary

trary if the river winds and often changes its direction, they are certain of not being far from the ſea. Mr. Fabry has himſelf verified this remark, in his travels over that unknown and almoſt uninhabited country. There is ſtill another remark which may be uſeful in like caſes, which is, that in large rivers, there is a conſiderable eddy along the banks, which is ſo much the more conſiderable, as the river is leſs remote from the ſea, and as the bed of the river is broader, which may alſo ſerve as a guide to judge whether we are at a great or ſhort diſtance from the mouth, and as the windings of rivers increaſe in proportion as they approach the ſea ; it is not ſurprizing that ſome of theſe windings opening, form mouths, by which a part of the waters get to the ſea, and this is one reaſon why great rivers generally divide into many arms to gain the ſea.

The motion of the waters in the courſe of rivers, is made in a quite different manner from that ſuppoſed by authors who attempt to give mathematical theories on this matter : not only the ſurface of a river in motion is not level when taken from one bank to the other, but even, according to circumſtances, the current which is in the middle is conſiderably higher or lower than the water cloſe to the banks ; when a river ſwells all of a ſudden by the melting of ſnow, or when by ſome other cauſe its rapidity is augmented, if the direction of the river is ſtrait, the middle of the water where the current is, riſes, and the river forms a convex curb, or a very ſenſible elevation, the higheſt point of which is in the middle of the current. This elevation is ſometimes very conſiderable, and M. Hupeau, an able engineer of Bridges, told me he had once meaſured the difference of the level of the water on the banks of the Aviron, and of that of the current or middle of the ſaid river, and had found the difference to be three feet, ſo that the middle of the Aviron was three feet higher

than near the bank. This, in fact, must happen every time the water has a very great rapidity; the velocity with which it is carried diminishing the action of its weight; the water which forms the current is not in equilibrium throughout its whole weight with the water which is near shore, which causes it to be higher. On the other hand, when rivers approach their mouths, it very often happens that the water which is near the banks is higher than that of the middle; although the current is rapid, the river then appears to form a concave curb, whose lowest point is in the strongest part of the current. This happens every time that the action of the tide is felt in a river. It is known, that in great rivers the motion of the waters occasioned by the tide is insensible at 1 or 200 miles from the sea; it is also known, that the current of a river preserves its motion in the middle of the sea to a considerable distance; there is in this case therefore two contrary motions in a river, the middle which forms the current precipitates itself towards the sea, and the action of the tide forms a counter-current, which causes the water near the banks to ascend, while that in the middle descends, and as then all the water in the river must pass by the current in the middle; that of the banks continually descends thereto, and descends so much the more as it is higher, and counteracted with more force by the tide.

There are two kinds of ebbings in rivers, the first, above-mentioned, is a strong power like that of the sea in tide, which not only opposes itself as an obstacle to the motion of a river, but as a body in motion, and in motion contrary and opposite to that of the current of a river; this forms a counter-current so much the more sensible as the tide is stronger; the other kind of ebbing has only a dead force for its cause, as a projection of land, the bed of a river, &c. As this does not commonly occasion a very sensible current, yet

yet it is ſufficient to be perceived, and even to tire thoſe who have the management of craft, boats, &c. if this kind of ebbing does not alway form a counter-current, it neceſſarily produces what is called a *morte*, i. e. ſtill waters which do not flow like the reſt of the river, but which whirl in ſuch a manner, that when boats are drawn therein, they require great ſtrength to get them out.

Theſe are very perceptible at the arches of bridges in rapid rivers. The velocity of the water increaſes as is known, in proportion as the diameter of the channel through which it paſſes diminiſhes, the impelling force being ſuppoſed the ſame; the velocity of a river therefore increaſes at the paſſage of a bridge, in an inverted ratio of the ſum of the breadth of the arches to the whole breadth of the river; the augmentation of the rapidity of water being therefore very conſiderable in coming through the arch, that which is on the eaſt ſide is drove laterally and againſt the banks of the river, and by this re-action a ſtrong whirling motion is formed. When we go through the bridge St. Eſprit, the men are forced to be careful not to loſe the ſtream, even after they are paſt the bridge, for if they ſuffer the boat to go either to the right or left, it might be drove againſt the ſhore with great danger. When this eddy cauſed by the current, and the oppoſite motion of the water is very conſiderable, it forms a kind of ſmall gulph, and in rapid rivers we often ſee at the fall of the water, below the ſtarlings of a bridge, that ſmall gulphs or whirl-pools are formed, the middle of which appears hollow and to form a kind of cylindrical cavity, around which the water whirls with rapidity: this appearance of cylindrical cavity is produced by the centrifugal force, which cauſes the water to endeavour to remove itſelf from the center of the whirlpool.

When

When a great ſwell of water happens, the watermen perceive it by a particular motion; they then ſay that the river *mouve de fond*, i. e. the water at the bottom flows quicker than common: this augmentation of rapidity at the bottom, according to them, always announces a ſudden riſe of the water. The motion and weight of the upper water communicates this motion to them; for in certain reſpects, we muſt conſider a river which is contained and flows in its bed, as a pillar of water contained in a tube, and the whole ſtream as a very long canal, where every motion muſt be communicated from one end to the other. Now, independent of the motion of the upper waters, their weight alone might cauſe the rapidity of the river to increaſe, and perhaps move it at bottom: for it is known, that by putting many boats at one time into the water, at that inſtant we increaſe the rapidity of the under part of the river as well as retard that of the upper.

The rapidity of running waters, does not exactly, nor even nearly follow, the proportion of inclination. One river whoſe inclination is uniform and double that of another, ought according to appearance, to flow only as rapid again, but in fact, it flows much faſter. Its rapidity inſtead of being doubled, is either triple or quadruple, &c. This rapidity depends much more on the quantity of water and the weight of the upper water than on the inclination, and when we are deſirous to hollow the bed of a river, &c. we muſt not equally diſtribute the inclination throughout its whole length, it is neceſſary, in order to give more rapidity to the water, to make the inclination much ſtronger at the beginning, than at the mouth where it muſt be almoſt inſenſible, as we ſee it in rivers; when they approach towards their mouths the inclination is but trifling, and yet they

they ſtill preſerve a rapidity ſo much the greater as the river is fuller of water, ſo that in great rivers, where the ground is level, the water does not ceaſe flowing, and even rapidly, not only by the acquired velocity, but alſo by the action and weight of the upper waters. To render this truth better conceivable, let us ſuppoſe that the part of the Seine between the Pontneuf and Pont royal was perfectly level and ten feet deep throughout: let us then for a moment ſuppoſe, that we could inſtantaneouſly leave the bed of the river below Pont-royal and above Pont-neuf entirely dry, then the water between theſe two bridges, although we have ſuppoſed them perfectly level, will flow on the two ſides, and will continue to flow till it is exhauſted; for although it is level, as it is loaded with a weight of ten foot water, it will flow from the two ſides with a rapidity proportionable to its weight, and this rapidity diminiſhing as the quantity of water diminiſhes, it will only ceaſe flowing when it ſhall have ſunk to the level of the bottom; the weight of water therefore greatly contributes to its velocity, and this is the reaſon that the greateſt rapidity of the current, is neither at the ſurface nor at the bottom of the water, but nearly in the middle of its depth, becauſe it is produced by the action of its weight, which is at its ſurface, and by the re-action of the bottom. There is even ſomething more, which is, that if a river had acquired a very great rapidity, it might not only preſerve it by paſſing over a level ground, but even it would be in a ſtate of ſurmounting an eminence without ſpreading much on both ſides, or at leaſt without cauſing a great inundation.

We might be inclined to think that bridges, locks, and other obſtacles raiſed on rivers, conſiderably diminiſhes the whole velocity of the water's courſe, nevertheleſs that cauſes but little difference. Water riſes on meeting with the ſtarling of a bridge; this elevation cauſes it to act the more by its weight, the

the which augments the velocity of the current between the piles, ſo much the more as the piles are broader and the arches narrower, ſo that the retardment which theſe obſtacles cauſe to the total velocity of the water's courſe, is almoſt inſenſible. The ſinuoſities, projections and iſlands likewiſe but very little diminiſh the like velocity : but what produces a very conſiderable diminution, is the ſinking of the water, as, on the contrary the augmentation of the volume of water increaſes this velocity more than any other cauſe.

If rivers were nearly of an equal fulneſs, the beſt means of diminiſhing the velocity of the water and confining them, would be to enlarge the channel : but as almoſt all rivers are ſubject to increaſe and diminiſh, to confine them therefore we muſt retrench the channel, becauſe in ſhallow waters, if the channel is very broad, the water which paſſes in the middle, hollows a bed there, forms ſinuoſities, and when it begins to ſwell, follows the direction it took in this particular bed. It ſtrikes forcibly againſt the banks of the channel, deſtroys them and does great injuries. Theſe effects of the water's fury might in ſome meaſure be prevented, by making at particular diſtances ſmall gulphs in the earth, i. e. by carrying the ground of one of theſe banks to a certain diſtance in the land; in order that theſe gulphs might be advantageouſly placed, they muſt be made, in the obtuſe angle of the ſinuoſities of the river, for then the current of the water turns and whirls in theſe little gulphs, which diminiſhes the velocity of it. This mode might perhaps be very proper to prevent the fall of bridges in places where it is not poſſible to make bars near the bridge which ſuſtain the action of the weight of the water. The gulphs we mention diminiſhes its current ; thus both would nearly produce the ſame effect, i. e. the diminution of velocity.

The

The manner in which inundations are made merit a peculiar attention; when a river ſwells, the velocity of the water always increaſes more and more till the river begins to overflow, at that inſtant, the velocity of the water diminiſhes, which cauſes that the overflowing once begun, an inundation always enſues, which remains for ſeveral days; for when even a leſs quantity of water comes after the overflowing than before, the inundation will ſtill be made, becauſe it depends much more on the velocity of the water, than on the quantity which comes thereto; if it was not ſo, we ſhould often find rivers overflow for an hour or two and then return to their beds, which never occurs, the inundation always remaining for ſeveral days, whether the rain ceaſes or a leſs quantity of water is brought, becauſe the overflowing has diminiſhed the velocity, and that conſequently the like quantity of water being no longer carried in the ſame time as before, is as if a greater quantity had came there. It might be remarked on the occaſion of this diminution, that if a conſtant wind blows againſt the current of the river, the inundation will be much greater than it would have been without this accidental cauſe, which diminiſhes the velocity of the water: as on the contrary, if the wind blows in the ſame direction which the current of the river follows, the inundation will be much leſs, and will more readily diminiſh. (See M. Granger on the overflowing of the Nile.)

"The ſwelling of the Nile and its inundations has a long time employed the learned; moſt of them have only looked upon as marvellous the moſt natural things, and what is every day to be ſeen in every country throughout the world. It is the rain which falls in Abyſſinia and Ethiopia which cauſe the ſwelling and inundation of that river, though the north wind muſt be regarded as the primitive cauſe. 1ſt, Becauſe it drives the clouds which convey this rain from

from the coaſt of Abyſſinia : 2dly; becauſe blowing againſt the two mouths of the Nile, it cauſes the waters to return againſt the ſtream and thus prevents them from pouring into the ſea in too great a quantity : this circumſtance may be every year relied on, when the wind being at the north, and ſuddenly veering to the ſouth, the Nile in one day loſes what it gathered in four.

Inundations are generally greater in the upper parts of rivers than in the lower parts, and thoſe near their mouth, becauſe all things being equal elſewhere, the velocity of a river continues always increaſing to the ſea, and although its inclination generally diminiſhes ſo much the more as it is nearer the mouth : nevertheleſs the velocity is often greater for the reaſons we have related. Father Caſtelli who has written very ſenſibly on this ſubject, rightly remarks, that the height of the banks made to confine the Po, diminiſhes towards the ſea, ſo that at Ferrara, which is 50 or 60 miles from the ſea, they are near 20 feet high above the common ſurface of the Po, whereas that lower at 10 or 12 miles diſtance they are not above 12 feet, although the channel of the river is as narrow there as at Ferrara, (See Racolta d'autori che trattanc del motto dell' acque, vol. 1, page 123.

On the whole, the theory of the motion of running waters is ſtill ſubject to many difficulties and obſcurities, and it is very difficult to lay down particular rules which might be applied to every particular caſe. Experience is here more neceſſary than ſpeculation. We muſt not only know by experience the general effects of rivers, but we muſt alſo know in particular the river we have to do with, if we would reaſon juſtly, and make uſeful and durable work. The remarks I have above given are moſtly new : it is to be wiſhed that many and ſimilar obſervations were collected ; we might poſſibly come at the height of

of this matter, and lay down certain rules to confine and direct rivers, and prevent the ruin of bridges, locks, and other damages which the violent impetuosity of the water causes.

The greatest rivers in Europe are the Volga, which is about 650 miles in its course from Reschou to Astracan, on the Caspian Sea; the Danube, whose course is about 450 miles from the mountains of Switzerland to the Black Sea; the Don, which is 400 miles in course from the source of Sosna which it receives, to its mouth in the Black Sea; the Nieper, whose course is about 350 miles, and which flows into the Black Sea; the Duine, which is about 300 miles in its course, and goes into the White Sea, &c.

The greatest rivers in Asia are the Hoanho of China, whose course is 850 miles, taking its source at Raja-Ribron, and which falls into the sea of China, in the middle of the gulph Changi: the Jenisca of Tartary, which is about 800 miles extent, from the lake Selinga to the northern Sea of Tartary, the river Oby, which is about 600 miles from Lake Kila to the Northern Sea, beyond the strait of Waigats. The river Amour of eastern Tartary, which is about 575 miles in course, reckoning it from the source of the river Kerlon, which falls into it there, to the sea of Kamtschatka, where its mouth is. The river Menancon, whose mouth is at Poulo Condor, and which may be measured from the source of Longmu which falls into it; the river Kiam, whose course is about 550 miles, measuring it from the source of the river Kina, which it receives, to its mouth in the China Sea: the Ganges is also about 550 miles, and the Euphrates 500, taking it from the source of the Irma, which it receives. The Indus about 400 miles, and which falls into the Arabian Sea, at the western part of Guzarat. The Sirderoius, which is about 400 miles long, and falls into Lake Aral.

The greateſt rivers in Africa are Senegal, which is 1125 miles long, comprehending the Niger, which in fact is only a continuation of it, and by going back with the Niger to the ſource of Gombarou, which falls into the Niger. The Nile 970 miles long, and which derives its ſource in upper Ethiopia, where it makes many windings. There are alſo the Zaire and the Coanza, which is known as far as 400 miles, but which extends much farther into the Monoemugi: the Couama, of which about 400 miles is alſo known, and which comes farther from the country of Camera. The Quilmanci, whoſe entire courſe is 400 miles, and which derives its ſource in the kingdom of Gingiro.

The greateſt rivers of America, and whch are alſo the greateſt in the world, are the river Amazonia, whoſe courſe is 1200 miles, if we go up as far as the lake near Guanuço, 30 miles from Lima, where the Maragnon takes its ſource, and if we go as far as the ſource of the river Napo, ſome diſtance from Quito, the courſe of the river Amazonia is more than a thouſand miles.

It might be ſaid that the courſe of the river St. Laurence in Canada is more than 900 miles, from its mouth going back to the lake Ontaro and Erio, from thence to lake Huron, afterwards to the lake Alemipigo, and at laſt to the lake Aſſiniboils; the waters of theſe lakes falling one into another, and at laſt into St. Laurence.

The river Miſſippi more than 700 miles long from its mouth to ſome of its ſources, which are not remote from the lake Aſſiniboils juſt mentioned.

The river de la Plata more than 800 miles long, from the ſource of the river Parana, which it receives.

The river Oronoko more than 575 miles in length, reckoning from the ſource of the river Caketa, near Paſto, part of which falls into the Oronoko, and flows alſo towards the river Amazonia.

The

The river Madera, which falls into Amazonia, and is more than 660 or 670 miles.

To know nearly the quantity of water the ſea receives by all the rivers which fall into it, let us ſuppoſe that one half of the globe is covered by the ſea, and that the other half is land, which is pretty juſt; let us ſuppoſe alſo, that the mediate depth of the ſea, by by taking it throughout its whole extent, at about a quarter of a mile from Italy, is 230 fathom, the ſurface of all the earth being 1709, that is to ſay, 8012 miles; the ſurface of the ſea is 85,490506 ſquare miles, which being multiplied by $\frac{1}{4}$, the depth of the ſea, gives 21,372626 cubical miles for the quantity of water contained in the ocean. Now to calculate the quantity of water which the ocean receives from the rivers, let us take ſome great rivers whoſe rapidity and quantity of water are known to us: for example, the Po, which runs into Lombardy, and waters a tract of land 380 miles long, according to Riccioli: its breadth, before it divides into many mouths to fall into the ſea, is 100 perches, and its depth 10 feet: its rapidity is ſo great, that it runs four miles an hour; therefore the Po ſupplies the ſea with 200 cubical perches, or 4 millions 800 thouſand in a day; but a cubical mile contains 125 millions cubical perches; therefore 26 days is required to convey a cubical mile of water to the ſea; it remains therefore now to determine the proportion between the river Po, and all the rivers of the earth taken together, which is impoſſible to do preciſely. But to know it pretty exactly, let us ſuppoſe that the quantity of water which the ſea receives by the large rivers in all countries, is proportional to the extent and ſurface of theſe countries, and that conſequently the country watered by the Po, and other rivers which fall therein, is in the ſame proportion on the ſurface of the whole earth, as the Po is to all the rivers of the earth. Now by

by the moſt correct maps, the Po, from its ſource to its mouth, traverſes a tract 380 miles long, and the rivers which fall therein on each ſide, proceed from the ſprings and rivers 60 miles diſtant from the Po: therefore this great river, and the others it receives, waters a tract 380 miles long, and 120 miles broad, which makes 45,600 ſquare miles, but the ſurface of all the dry land is 85,490506 ſquare miles; conſequently all the water which the rivers carry to the ſea, will be 1870 times greater than the quantity which the Po furniſhes us with; but as 26 rivers like the Po furniſhes a cubical mile of water to the ſea in a day, 1874 rivers like the Po, would ſupply the ſea with 26,308 cubical miles of water in a year, and that in the ſpace of 112 years all the rivers would ſupply the ſea with 21,372626 cubical miles of water; that is to ſay, as much as there is in the ocean, and therefore 112 years is only required to fill it. (*See Ikeil, Examination of Burnet's Theory*, 1774, *page* 126.)

There reſults from this calculation, that the quantity of water evaporated from the ſea, and which the winds convey on the earth, producing rivulets, ſtreams, and rivers, is about 245 lines, or from 20 to 21 inches a year, or about two-thirds of a line each day; this is a very trifling evaporation when even doubled or trebled, in order to eſtimate the water which refalls on the ſea, and which is not conveyed over the earth. *See Halley in Phil. Trans, page* 192, where he evidently and by calculation ſhews, that the vapours which riſe above the ſea, and which the winds convey over all the earth, are ſufficient to form all the rivers, and to contain all the waters which are on the ſurface of the earth.

Next to the Nile the river Jordan is the moſt conſiderable in the Levant, and even in Barbary; it ſupplies the ſea with about ſix million tons of water every day: all this water and more is raiſed by evaporation,

poration; for, according to Halley's calculation, we find, that the ſea there, which is 72 miles in length by 18 broad, muſt every day loſe near nine million tons of water by evaporation; that is to ſay, not only all the water it receives from the river Jordan, but alſo that of the ſmall rivers, which come into it from the mountains of Moab and elſewhere; conſequently it does not communicate with any other ſea by ſubterraneous canals. *See Shaw's Travels, vol.* 11, *page* 71.)

The moſt rapid rivers are the Tiger, the Indus, the Danube, the Yrtis in Siberia, the Malmitra in Sileſia, &c. but as we have in the beginning of this article obſerved, the proportion of the rapidity of rivers depends upon two cauſes, 1ſt, the inclination, and 2dly, the weight and quantity of water, by examining which is moſt inclined, we ſhall find, that the Danube is much leſs ſo than the Po, the Rhine, and the Rhone, ſince deriving ſome of its ſources from the ſame mountains, the Danube has a much longer courſe than any of theſe other rivers, and falls into the Black Sea, which is higher than the Mediterranean, and perhaps more ſo than the ocean.

All large rivers receive many others in the extent of their courſe; for example, the Danube is reckoned to receive more than 200 rivulets and rivers, but by not reckoning what the rivers nearly as large as theſe receive, we ſhall find that the Danube receives 31, the Volga 32, the Don 5 or 6, the Nieper 190, the Dreine 11 or 12; and ſo likewiſe in Aſia the Hoanho receives 34 or 35, the Jeniſca 60, the Oby as many, the Amour about 40, the Kiam or river Nanguin about 30, the Ganges upwards of 20, the Euphrates 10 or 11, &c. In Africa the river Senegal receives upwards of 20 rivers; the Nile does not receive any river for upwards of 500 miles from its mouth; the laſt which falls therein is the Mora, and from this place to its ſource it receives about 12 or

or 13 rivers. In America the river Amazonia receives more than 60, all of which are very conſiderable; the river St. Laurence about 40, by reckoning thoſe which fall into the lakes; the river Miſſippi more than 40, and the river Plata more than 50, &c.

There are high countries on the earth which ſeem to be points of diviſion, marked by nature for the diſtribution of the waters. The environs of mount St. Goddard are one of theſe points; another is ſituate between the provinces of Belozera and Vologda in Muſcovy, from whence rivers deſcend, ſome of which go to the White Sea, others to the Black, and ſome to the Caſpian. In Aſia, the country of Mogul Tartary, from whence rivers flow, ſome of which run into the Calm Sea, or Sea of Nova Zembla, others to the Gulph Linchidolin, others to the Sea Corea, others to that of China, and ſo likewiſe the Little Thibet, whoſe warers flow towards the ſea of China, the gulph of Bengal, the gulph of Cambay, the lake Aral; in America the province of Quito, which ſupplies with waters the South Sea, and the gulf of Mexico.

In the old continent there is about 430 rivers, which fall directly into the ocean, or into the Mediterranean and Black Sea, and in the new continent, ſcarce 180 rivers are known, which fall directly into the ſea: on the whole in this number I have comprehended only the great rivers, like the Somme in Picardy.

All theſe rivers carry to the ſea a great quantity of mineral and ſaline parts, which they have waſhed from the different ſoils through which they have paſſed. The particles of ſalt which as is known are eaſily diſſolved, are conveyed to the ſea by the water. Some phyſicians, and among the reſt Halley, have pretended that the ſaltneſs of the ſea proceeded only from the ſalts of the earth, which the rivers tranſport therein. Others aſſert, that the ſaltneſs of the

the ſea is as antient as the ſea itſelf, and that this ſalt was created only that it might not corrupt, but it may judiciouſly be ſuppoſed that the ſea is preſerved from corruption by the agitations of the wind, and the flux and reflux, as much as by the ſalt it contains; for when it is kept in a barrel, it corrupts in a few days, and Boyle relates that a mariner becalmed for 13 days, found at the end of that time the ſea ſo infected, that if the calm had not ceaſed, the greateſt part of his people on board would have periſhed. Vol. 3, page 222. The water of the ſea is alſo mixed with a bituminous oil, which gives it a diſagreeable taſte, and renders it very unhealthful. The quantity of ſalt contained in ſea water, is about 1-40th part, and the ſea is nearly equally ſaline throughout at top as well at the bottom, under the line, and at the Cape of Good Hope, although there are ſeveral parts as on the Moſambaic Coaſt, where it is ſalter than elſewhere. See Boyle, vol. 3, page 217. It is alſo aſſerted, not to be ſo ſaline under the Arctic Zone, which may proceed from the great quantity of ſnow, and the great rivers which fall into thoſe ſeas, and becauſe the heat of the ſun produces but little evaporation there, in compariſon of the evaporation which is made in hot climates.

Be it as it may, I imagine that the true cauſe of the ſaltneſs of the ſea are not only the banks of ſalt at the bottom of the ſea, but alſo the ſalts of the earth, which the rivers continually convey therein, and that Halley had ſome reaſon to preſume that in the beginning of the world, the ſea had but little or no ſaltneſs; that it is become ſo by degrees, and in proportion as the rivers have brought ſalts therein: that this ſaltneſs perhaps is every day increaſing, and that conſequently he has concluded that by making experiments to diſcover the quantity of ſalt in a river where it reaches the ſea; and that by computing the quantity of water brought thereto by all the rivers

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we ſhould attain the knowledge of the age of the world by the degree of the ſaltneſs of the ſea.

Divers pearl fiſhermen aſſert, according to Boyle, that the deeper they deſcend into the ſea, the colder is the water; that the cold is even ſo intenſe at a conſiderable depth, that they cannot bear it, which is the reaſon they do not remain ſo long under water, when they deſcend to a great depth, as when they deſcend to only a moderate one. It appeared to me that the weight of the water might be the cauſe as well as the cold, if they deſcended to a very great depth, as 3 or 400 fathom; but in fact divers never deſcend above an hundred feet, or thereabouts. The ſame author relates, that in a voyage to the Eaſt-Indies, beyond the line at about 35 degrees ſouth latitude, a ſounding lead of 30 or 35lb. weight, was ſunk to the depth of 400 fathom, and that being pulled up again, it had become as cold as ice. It is alſo known, that travellers to cool their wine, ſink their bottles to the depth of ſeveral fathom, and the deeper they are ſunk, the cooler is the wine.

All theſe circumſtances might make us preſume that the ſea is ſalter at the bottom than at the ſurface; nevertheleſs we have teſtimonies which aſſert the contrary: and founded on experiments made to fill veſſels with ſea water, which were not unſtopped till they were ſunk to a certain depth, but the water was found to be no ſalter than at the ſurface. There are even ſome places where the water at the ſurface being ſalt, that at the bottom is ſweet, and this muſt always be the caſe in thoſe places, where there are ſprings at the bottom of the ſea, as near Gou, Ormur, and even in the ſea of Naples, where there are hot ſprings at the bottom.

There are other places where bituminous ſprings, and beds of bitumen, have been diſcovered at the bottom of the ſea, and on land there are many of theſe ſprings which have bitumen mixed with ſea water.

water. At Barbadoes there is a pure bitumen ſpring, which flows from the rocks to the ſea : ſalt and bitumen therefore, are predominant matters in the ſea, but it is alſo mixed with many other matters; for the taſte of water is not the ſame in every part of the ſea, beſides the agitation and the heat of the ſun alters the natural taſte, which the ſea ſhould have; and the different colours, of different ſeas, at different times proves that the water of the ſea contain ſeveral kinds of matters, either which it looſens from its own bottom, are brought thither by rivers.

Almoſt all countries watered by great rivers, are ſubject to periodical inundations, particularly thoſe which are low, and near their mouths, and rivers which derive their ſources from a great diſtance overflow the moſt regularly. Every perſon almoſt has heard mention made of the Nile, it preſerves the ſweetneſs and whiteneſs of its waters, a great way in the ſea. Strabo and other ancient authors, have written that it had ſeven mouths, but there now remains only two which are navigable, there is a third canal which deſcends to Alexandria to fill the ciſterns there and a fourth canal which is ſtill ſmaller, but as they have for a long time neglected to clean their canals, they are both choaked up ; the ancients employed a great number of workmen and ſoldiers, and every year, after the inundation, they carried away the mud and ſand which was in the canals. The cauſe of the overflowing of the Nile proceeds from the rains which falls in Ethiopia. They begin in April and do not ceaſe till September, during the three firſt months, the weather is ſerene and fair, but as ſoon as the ſun goes down, it rains till it riſes again, when it is generally accompanied with thunder and lightning. The inundation begins in Egypt about the 17th of June, it generally increaſes during 40 days, and diminiſhes in about the ſame time : all the flat country of Egypt is

innundated: but this inundation is much leſs now than it was formerly, for Herodotus, tells us that the Nile was 100 days in ſwelling and as many in abating: if this is true, we can only attribute the cauſe thereof, to the elevation of the land, which the mud of the waters has heightened by degrees, and to the diminution of the mountains in Africa, from whence it derives its ſource; it is very natural to imagine, that theſe mountains have diminiſhed, becauſe the abundant rains which fall in theſe climates during half the year, ſweep away the ſand and earth from the mountains into the vallies, from whence the torrents waſh them away into the Nile, which carries a good part into Egypt, where it depoſits them in its oveflowings.

The Nile is not the only river whoſe inundations are periodical and annual, the river Pegu, is called the *Indian Nile*, becauſe it overflows regularly every year; it inundates this country for more than 30 miles from its banks: and like the Nile, leaves a mud, which ſo greatly fertilizes the earth, that the paſturage there is excellent for cattle, and rice grows there in ſuch great abundance, that every year, a great number of veſſels are laden with it, without leaving a ſcarcity in the country. (See *Ovington's travels. Vol. II.Page* 290.) The Niger, or what amounts to the ſame, upper part of Senegal river, likewiſe overflows like the Nile, and the inundation which covers all the flat country of Nigritia, begins nearly at the ſame time as the Nile, and increaſes alſo for 40 days: The river de la Plata at Braſil, alſo overflows every year, and at the ſame time as the Nile. The Ganges, the Indus, and the Euphrates and ſome more alſo overflow annually, but all other rivers have no periodical overflowings, and when inundations happen, it is the effect of many cauſes which combine to ſupply a greater quantity of water than common, and at the ſame time, to retard the velocity of the river.

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We have before obſerved that in almoſt all rivers, the inclination of their beds always diminiſhes towards their mouths in an inſenſible manner; but there are ſome whoſe inclination is very ſudden in ſome places, and which form what is termed a *cataract*, which is nothing more than a fall of water quicker than the common current of a river. The Rhine for example has two cataracts, the one at Bilefield, and the the other near Schafhouſe : the Nile has many, and among the reſt two which are very violent, and fall from a great height between two mountains; the river Vologda in Muſcovy has alſo two near Ladoga; the Zaira, a river of Congo begins by a very ſtrong cataract which falls from the top of a mountain; but the moſt famous, is that of Niagara in Canada, it falls from a perpendicular height of 156 feet, like a prodigious torrent, and is more than a quarter of a mile broad : the fog or miſt, which the water makes in falling, is perceived at five miles diſtance, and riſes as high as the clouds, forming a very beautiful rainbow, when the ſun ſhines thereon. Below this cataract there are ſuch terrible whirlpools, that nothing can be navigated thereon for ſix miles diſtance, and above the cataract the river is much narrower than it is in the upper lands. (See *Phil. Tranſ. Abr. Vol. VI. Part II. Page* 119,) and the deſcription given by *Father Charlevoix*.

" My firſt care was to viſit the moſt beautiful caſcade that is perhaps in nature, but I immediately diſcovered that Baron la Hontain was deceived ſo greatly, both in its height and figure, that one might reaſonably imagine he never ſaw it.

" It is true, that if we meaſure its height, by the three mountains which it muſt firſt fall over, there is not much abatement to be made of the 600 feet, which the map of M. Deliſſe gives it, who doubtleſs advanced this paradox only on the credit of the Baron la Hontain and father Hennepin; but after I arrived

rived at the top of the third mountain, I obſerved, that in the ſpace of three miles which I afterwards made to this fall of water, altho' it muſt ſeveral times aſcend, yet it muſt more ſo deſcend, and this is what travellers have not paid a proper attention to, as we can only approach the caſcade on one ſide nor ſee it but in the profile, it is not eaſy to meaſure its height by inſtruments: we endeavoured to do it therefore by a long cord tied to a pole, and after having often attempted this manner, we found it to be only 105 or 120 feet deep, but it is not poſſible to aſcertain whether the pole was not ſtopped by ſome projection of the rock, for altho' we always drew it up again with the end of the cord wet, yet that is no proof, ſince the water which precipitates from the mountains, flies up again in form to a very great height: for my own part, after having conſidered it on every ſide that I could examine it at my eaſe, I eſtimate that we cannot allow it to be leſs than 140 or 150 feet.

"Its figure is that of an horſe ſhoe, it circumference about 100 paces; but exactly in its middle, it is divided by a very narrow iſland, about half a quarter of a mile long It is true theſe two parts join again, that which was on my ſide, and ſeen only in the profile, has many projecting points, but that which I diſcovered in front, appeared very even." See page 332, &c Vol III.

There is another cataract three miles from Albany, in the province of New York; its height is 150 feet perpendicular, and from this waterfall there ariſes alſo a miſt in which a faint rainbow is ſeen, which changes ſituation in proportion as we are nearer or farther from it, Phils. Tranſ. Vol. VI. Part II. Page 19.

In general, in all countries, where mankind are not numerous enough to form poliſhed ſocieties, the ground is more irregular, and the beds of rivers more

more extended, leſs equal, and filled with cataracts; many ages were required to render the Rhone and Loire navigable. It is by confining waters, by directing their courſe, and by cleanſing the bottom of rivers, that we give them a fixed courſe; in all countries thinly inhabited, nature is rude, and often deformed.

There are rivers which loſe themſelves in the ſands, and others which ſeem to precipitate into the bowels of the earth: the Guadalquiver in Spain, the river Gottenburg in Sweden, and the Rhine itſelf loſe themſelves in the earth. It is aſſerted, that in the weſt part of St. Domingo, there is a mountain of a conſiderable height, at the foot of which are many caverns or rivers, and the rivulets fall with ſo much noiſe, as to be heard at the diſtance of ſeven or eight miles. See Varenii Geograph. gen. page 43.

In the whole the number of rivers which loſe themſelves in the earth, is very few, and there is no appearance that theſe waters deſcend very low into the globe; it is more probable that they loſe themſelves like the Rhine, by dividing among the ſands, which is very common to ſmall rivers which water dry and ſandy ſoils, of which we have ſeveral examples in Africa, Perſia, Arabia, &c.

The rivers of the north tranſport into the ſea a prodigious quantity of flakes of ice, which accumulating, form thoſe enormous maſſes of ice ſo deſtructive to mariners; one part of the frozen ſea where they are the moſt abundant, is the ſtrait of Waigats, which is entirely frozen over the greateſt part of the year; this ice is formed from the great flakes which the river Oby almoſt continually bring there: they attach themſelves along the coaſts, and heap up to a conſiderable height on both ſides of the Strait, but the middle of the Strait is the laſt part of it, which freezes, and where the ice is the loweſt. When the wind ceaſes to blow from the north, and

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comes according to the direction of the Strait, the ice begins to thaw and break in the middle ; afterwards it loosens from the sides in great masses, which go into the high sea. The wind, which all winter comes from the south, and passes over the frozen countries of Nova Zembla, renders the country watered by the Oby, and all Siberia, so cold, that even at Sobolok, which is in the 57th degree, there are no fruit trees, while at Sweden, Stockholm, and even in the highest latitudes, there are both fruit trees and pulse : this difference does not proceed, as is thought, because the sea of Lapland is warmer than the Strait; or that the land of Nova Zembla is more so than Lapland, but solely from the Baltic, and the gulph of Bethnia, which tempering a little the rigour of the north winds, whereas in Siberia there is nothing which can temperate the cold. What I here say is founded on good observations : it is never so cold on the sea coasts as in the inland parts. There are plants which stand the winter in London exposed to the open air, and which cannot be preserved at Paris ; and Siberia, which is a vast continent that the sea does not enter, it for this reason colder than Sweden, which is surrounded on all sides by the sea.

The coldest country in the world is Spitzbergen : it lies in 78 degrees latitude, entirely formed of small peaked mountains : these mountains are composed of gravel, and flat stones heaped one on the other : as travellers assert, by the wind : they increase very quick, and mariners discover new ones every year. The Rein deer is the only animal seen here, which feeds on a short grass and moss. On the top of these little mountains, and at more than a mile from the sea, a mast was found, with a pulley fastened to one of its ends, which gives room to suppose that the sea once washed the tops of the moun-

mountains, and that this country is but of modern date : it is inhabited and inhabitable ; the ſoil of theſe ſmall mountains has no bond, and ſo cold and penetrating a vapour ſtrikes from it, that a perſon is frozen by remaining a ſhort time thereon.

The veſſels which go to Spitzbergen for the whale fiſhery, get there in the month of July, and take their departure from it about the 15th of Auguſt, the ice hindering the veſſels from entering that ſea earlier, and to quit it after that time. Prodigious pieces of ice, 60, 70, and 80 fathom thick, are ſeen there, and there are ſome parts of it where the ſea appears frozen to the very bottom ; this ice, which is ſo high above the level of the ſea, is as clear and tranſparent as glaſs.

There is alſo much ice in the ſeas of North America, as in the bay of Aſcenſion, in the bays of Hudſon, Cumberland, Davis, Forbiſhers, &c. Robert Lade aſſerts, that the mountains of Friezland are entirely covered with ſnow, and all the ſides with ice, like a bulwark, which will permit no one to approach it. " It is, ſays he, very remarkable that in this ſea we meet with iſlands of ice, more than half a mile round, extremely high, and 70 or 80 fathom deep in the ſea ; this ice, which is ſweet, is perhaps formed in the ſtraits of the neighbouring lands, &c. Theſe iſlands or mountains of ice, are ſo mobile, that in ſtormy weather, they follow the track of a ſhip as if they were carried along in the ſame furrow. There are ſome ſo large that their ſuperficies above the water ſurpaſſes the end of the maſts of the largeſt veſſels, &c. See the voyages of Lade. Vol. 11. page 305, &c.

In the collection of voyages which have been ſerviceable towards the eſtabliſhment of the Dutch Eaſt-India company, we meet with a ſmall hiſtorical journal of the ice at Nova Zembla, of which the following is an extract. " At Cape Froſt the weather

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was ſo foggy as to oblige us to moor the veſſel to a mountain of ice, which was 36 fathom deep in the water, and about 16 fathom out of it, ſo that it was on the whole 52 fathom thick.

"The 10th of Auguſt, the ice dividing, it began to float, and then we obſerved that the large piece of ice to which the ſhip had been moored, touched the bottom, as all the reſt paſſed by it, and ſtruck it without moving it. We then began to fear, being incloſed between the ice, and endeavoured to avoid the danger, by mooring to another large piece of ice till night.

"After we had refreſhed ourſelves, during the firſt watch the ice began to ſplit with ſo terrible a noiſe, as is inexpreſſible, and the ice which was now floating in the current obliged us to cut the cable to avoid it: we reckoned no leſs than 400 large mountains of ice, which were 10 fathoms under water, and appeared more than two fathom above.

"We afterwards moored the veſſel to another mountain of ice, which was above ſix fathoms under water. As ſoon as we were fixed, we perceived another piece beyond us, whoſe height terminated in a point like a ſteeple, though it touched the bottom of the ſea, we advanced towards this mountain of ice, and found it 20 fathoms under water, and near 12 above.

The 11th of Auguſt we reached another large ſhelve of ice, 18 fathom under water, and 10 above.

"The 21ſt, the Dutch got pretty far in among the ice, and remained there the whole night; the next morning they moored their veſſel to a ſhelve of ice, which they aſcended, and admired its figure as a very ſingular thing. This ſhelve was covered with earth at top, and they found near 40 eggs thereon. The colour was not the common colour of ice, but a

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ſky blue. Thoſe who were on it, reaſoned much concerning it, ſome ſaying it was an effect of the ice, while others maintained it to be a frozen earth. Be it as it may, this mountain of ice was extremely high, about 18 fathom under water, and 10 above." P.46, &c. Vol. 1, 3d voyage of the Dutch to the North.

Wafer relates, that near Terra del Fuega he met with many high floating pieces of ice, which he at firſt miſtook for iſlands. Some appeared a mile or two in length, and the largeſt of all appeared 4 or 500 feet high. (See Wafer's voyage, Vol. 4, page 304.)

All this ice, as I have obſerved in the 6th article, was brought thither by the rivers; the ice in the ſea of Nova Zembla, and the Strait of Waigats came from the Oby, and perhaps from Jeniſca, and other great rivers of Siberia and Tartary; that in Hudſon's Bay, from Aſcenſion Bay, where many of the North American rivers fall in; that of Terra del Fuega came from the ſouthern continent; and if there is leſs on the coaſts of North Lapland, than on thoſe of Siberia, and the Strait of Waigats: altho' North Lapland is nearer the Pole, it is becauſe all the rivers of Lapland fall into the gulph of Bythnia, and now go into the northern ſea. The ice may alſo be formed in the ſtraits, where the tides ſwell much higher than in the open ſea, and where conſequently the ice which is at the ſurface may heap up and form thoſe mountains of ice ſeveral fathoms high: but with reſpect to thoſe which are 4 or 500 feet high, they appear to me not to be formed on high coaſts, and I imagine that when the ſnow which covers the top of theſe coaſts melts, the water flows on the flakes of ice, and are likewiſe frozen thereon, and thus increaſes the ſize of the firſt to that height of 4 or 500 feet; that afterwards in a warmer ſummer, theſe hills of ice looſen from the coaſts by the action of the wind, and motion of the ſea, or perhaps even by

their new weight, and afterwards are driven as the wind directs, so that they at length may arrive into temperate climates before they are entirely melted.

PROOFS of the THEORY of the EARTH.

ARTICLE XI.

Of Seas and Lakes.

THE ocean surrounds the continents on all sides, and penetrates into the land in several places, often by large openings, and frequently by small straits: it forms the Mediterranean seas, some of which participate of its motions of flux and reflux, and others seem to have nothing in common with it except the continuity of water. We shall follow the ocean through all its extent and windings, enumerating at the same time all the Mediterranean seas, and endeavour to distinguish them from those which should be only called *Gulphs*, and also from those which ought to be regarded as Lakes.

The sea which washes the western coasts of France, forms a gulph between Spain and Brittany; this gulph, which mariners call the *Gulph of Biscay*, is very open, and the point of that gulph which projects farthest inland, is between Bayonne and Saint Sebastian; another very projecting part of the gulph washes the coasts from Aunis to Rochelle and Rochfort; this gulph begins at Cape Ortegal, and ends at Brest, where a strait commences between the point of Brittany and Cape Lizard: this strait, which at first is very large, forms a small gulph in Normandy, the most projecting point of which is at Avranches: the strait continues pretty broad to the foot of Calais, where it is very narrow; afterwards it grows broader on a sudden, and ends between the Texel and

and the coaſt of England at Norwich; at the Texel it forms a ſmall Mediterranean ſea, called *Zuyder-zee*, and many other great canals, which are not very deep, no more than the *Zuyder-zee*.

After that the ocean forms a great gulph, called the *German Ocean*, and this gulph, taken throughout all its extent, begins at the northern point of Scotland, deſcending all along the eaſtern coaſts of Scotland and England, as far as Norwich, from thence to the Texel, along the coaſts of Holland and Germany, Jutland, Norway, and above Berguen; this great gulph might alſo be taken for a mediterranean ſea, becauſe the Orcade iſlands partly ſhut up its opening, and ſeem to be directed as if they were a continuation of the mountains of Norway. This great gulph forms a large ſtrait, which begins at the ſouthern point of Norway, and continues very broad to to the iſland of Zeland, where it narrows all at once, and forms between the coaſts of Sweden, the iſlands of Denmark and Jutland, four ſmall ſtraits, after which it extends in breadth like a ſmall gulph, the moſt projecting point of which is at Lubec: from thence it continues pretty broad as far as the ſouthern extremity of Sweden, when it grows broader and broader, and forms the Baltic ſea, which is a Mediterranean, extending from ſouth to north near 300 miles, comprehending the gulph of Bothnia, which is in fact only a continuation of the Baltic Sea: this ſea has two more gulphs, that of Livonia, whoſe moſt projecting point is near Mittau and Riga; and that of Finland, which is an arm of the Baltic ſea, extending between Livonia and Finland, as far as Peterſbourgh, and communicates with the lake Ladoga, and even with the lake Onega, which communicates by the river Onega to the White Sea. All this extent of water which forms the Baltic Sea, the gulph of Bothnia, Finland, and Livonia, muſt be looked upon as one great lake,

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ported by the waters of the rivers which it receives in a very great number, as the Oder, the Vistula, the Niemen, the Droine in Germany and Poland, and many other rivers in Livonia and Finland; others still greater, which come from Lapland, as the river Tornea, the rivers Calis, Lula, Pitha, Uma, and many others which come from Sweden: these rivers, which are very considerable, are more than 40, including the rivers which they receive, which cannot fail of producing a very great quantity of water, which is probably more than sufficient to support the Baltic Sea; besides this sea has no flux and reflux, although it is very narrow and very salt. If we consider also the bearing of the country, and the number of lakes and morasses in Finland and Sweden, which are almost contiguous to that sea, we shall be inclined to look on it not as a sea, but as a great lake formed in the land by the abundance of waters, which have forced the passages near Denmark to run into the ocean, as they do in fact flow thither according to the account of mariners.

At the issue of the great gulf which forms the German ocean, and which terminates above Berguen, the ocean follows the coasts of Norway, Swedish Lapland, North Lapland, and Muscovy Lapland, at the eastern part of which a very large strait which borders a Mediterranean sea called the *White Sea*. This sea may be likewise regarded as a great lake; for it receives 12 or 13 rivers all very considerable, and which are more than sufficient to support it; it is a little salt, besides there is very little wanting to give it a communication with the Baltic Sea; it has even a real one with the gulph of Finland, for, by ascending the river Onega, we come to a lake of the same name; from this lake Onega there are two rivers of communication with the lake Ladoga: this last lake communicates by a large arm with the gulph of Finland, and there are many parts in Swe-

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diſh Lapland, the water of which run almoſt indifferently ſome towards the White Sea, others towards the gulph of Bothnia, and others towards that of Finland, and all this country being full of lakes and moraſſes, the Baltic and White Sea ſeem to be the receptacles of all theſe waters, which afterwards diſcharge themſelves into the frozen and German ſea.

Quitting the White Sea, and coaſting the iſland of Candenos, and the northern coaſts of Ruſſia, we find that the ocean forms a ſmall arm in the land at the mouth of the river Petzora. This ſmall arm, which is about 40 miles long by 8 or 10 broad, is rather a maſs of water formed by the river, than a gulph of the ſea, the water having but little ſaltneſs there. The land there forms a projecting cape, terminated by the ſmall iſlands Maurice and Orange, and between theſe lands, and thoſe which border the ſtrait of Waigats to the South, there is a ſmall gulf about 30 miles depth in land. This gulf belongs to the ocean, and is not formed by the land waters: we afterwards meet with the ſtrait of Waigats, which is nearly under the 70th degree northern latitude: this ſtrait is no more than 8 or 10 miles long, and communicates with a ſea which waters the northern coaſts of Siberia: as this ſtrait is ſhut up by the ice the greateſt part of the year, it is very difficult to get to the ſea beyond it. The paſſage of this ſtrait has been attempted in vain by a great number of navigators, and thoſe who fortunately paſſed it, have left us no exact charts of that ſea, which they have termed the *tranquil Ocean*. All that appears by the moſt recent charts, and by Senex's globe of 1739, is, that this ſea, might be entirely mediterranean, and not communicated with the great ſea of Tartary, for it appears to be encloſed and bounded on the ſouth by the country of the Samoides, which is at preſent well known, and thoſe lands which border it on the north extend from

from the ſtrait of Waigats, as far as the mouth of the river Jeniſca; on the eaſt it is bounded by Jelmoreland, and on the weſt by Nova Zembla, and although we are not acquainted with the extent of this Mediterranean ſea on the north ſide and north eaſt, as we are acquainted with the uninterrupted lands there, it is very probable that this tranquil ſea is a Mediterranean, a kind of a road very difficult of acceſs, in which there is no outlet: what proves this, is that by leaving Waigats ſtrait, and coaſting Nova Zembla in the frozen ſea all along its weſtern and northern coaſts as far as Cape Deſire; and that after having paſt this cape, keeping along the coaſt to the eaſt of Nova Zembla to a ſmall gulf, whch is about 75 degrees, where the Hollanders paſt a mortal winter in 1596; that beyond this gulf the country of Jelmorland was diſcovered in 1664, which is only ſome leagues diſtant from Nova Zembla, ſo that the only ſmall part which has not yet been diſcovered, is near the ſmall gulf we ſpeak of; and this part is perhaps not 30 leagues long: ſo that if the tranquil ſea communicated with the ocean, it muſt be at this little gulf, which is the only one by which this ſea can join to the Great Sea: and as this ſmall gulf is 75 degrees north, and that even if the communication ſhould exiſt, we muſt always aſcend five degrees towards the north to gain the Great Sea; it is evident that if we would acquire the northern rout to China, it would be much better to paſs by the north of Nova Zembla at 77 or 78 degrees; where alſo the ſea is more open and leſs icy; than to attempt the road through the icy ſtrait of Waigats, with the uncertainty of getting out of this Mediterranean ſea.

By following therefore the ocean along the coaſts of Nova Zembla and Jelmorand, theſe lands are diſcoverable as far as the mouth of Chotanga, which is about the 73d degree, after which we meet with

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a ſpace of about 200 leagues, whoſe coaſts are not yet known to us; we only meet with an account of them in the relations of the Muſcovites who have travelled by land into thoſe climates, and who mark out in their charts rivers and people which they have called *populi patati*, this interval of coaſts ſtill unknown is from the mouth of Chotanga as far as that of Kauvoina in the 66th degree latitude, the ocean there forms a gulph whoſe moſt projecting point in land, is in the mouth of the Len, which is a very conſiderable river, this gulf is formed by the waters of the ocean, it is very open and belongs to the Tartarian ſea, and is called the *Gulph Linchidolin*, where the Muſcovites have a whale fiſhery.

From the mouth of the Len we may follow the coaſts of Tartary in a ſpace of more than 500 leagues towards the eaſt as far as a great peninſula or projecting land, inhabited by the Schelates: this point is the moſt northern extremity of eaſtern Tartary, and is ſituate about the 72d degree northern latitude; in this length of more than 500 leagues the ocean makes no interruption into the land, no gulf, nor arm, bnt forms only a conſiderable elbow, at the origin of the peninſula of the Schelates; at the mouth of the river Kauvoina, this point of land alſo forms the eaſtern extremity of the old World; whoſe weſtern extremity is at the north Cape in Lapland; ſo that the old continent has about 1700 leagues northern coaſts, comprehending the ſinuoſities of the gulfs, & reckoning from the north cape of Lapland as far as the point of land belonging to Schelates, about 1100 leagues ſailing under the ſame parallel.

Let us now take a view of the eaſtern coaſts of the old continent, beginning at that point of land, which the Schelates inhabit, and deſcending towards the equator: the ocean at firſt forms an elbow between the Schelates and the land inhabited by the people called

called Tfcutfchi, which projects a confiderable way into the fea. To the fouth of this land, it forms a mall gulf called the *Gulf Suctoikret*, and afterwards another fmaller gulf which projects like an arm 40 or 50 miles into Kamtfchatka: after which the ocean enters into the land by a large ftrait, filled with many fmall iflands, between the fouthern point of Kamtfchatka and the northern point of Yeco, and forms a great mediterranean fea, which it is proper we fhould trace throughout. The firft is the fea of Kamtfchatka, in which is a very confiderable ifland called *Amour* or *Love Ifland*; this fea fends out an arm into the lands to the north eaft, but this fmall arm and the fea of Kamtfchatka itfelf, might poffibly be, at leaft in part, formed by the rivers, which run therein, as well from Kamtfchatka, as from Tartary. Be this as it will, the fea of Kamtfchatka communicates with the fea of Corea, which makes the fecond part of this mediterranean fea, and all this fea which is more than 602 leagues long, is bounded on the weft and on the north by Corea and Tartary, on the eaft and fouth by Kamtfchatka, Yeco and Japan, without having any other communication with the ocean than that of the forementioned ftrait; for it is not certain whether that fet down in fome maps between Japan and Yeco really exifts; and even if this ftrait does exift, the fea of Kamtfchatka and Corea, will ftill be always regarded as forming a great mediterranean fea divided from the ocean, on every fide; and which muft not be taken for a gulf, for it has no direct communication with the ocean by its fouthern ftrait between Japan and Corea. The fea of China, to which it communicates by this ftrait, is rather a mediterranean fea, than a gulf of the ocean.

We have obferved in the preceeding difcourfe, that the fea had a conftant motion from eaft to weft: and that confequently the great pacific fea made conti-

tinual efforts againſt the eaſtern countries, an attentive inſpection of the globe, will confirm the conſequences which we have drawn from this obſervation; for, if we examine the bearing of the land, from Kamtſchatka to New Britain, diſcovered in 1700 by Dampier, and which is 4 or 5 degrees from the equator, ſouth latitude, we ſhall be inclined to think that the ocean had waſhed away the land of theſe climates upwards of 400 leagues: that conſequently the eaſtern bounds of the old continent have been removed farther back, and that it formerly extended much farther towards the eaſt, for we ſhall remark, that New Britain and Kamtſchatka, which are the moſt projecting lands towards the eaſt, are under the ſame meridian; we ſhall obſerve, that all the lands are directed from north to ſouth, and that point which is waſhed by the pacific ſea on the the eaſt, and on the other, by the mediterranean ſea above mentioned, is divided in the direction from north to ſouth by a chain of mountains.

After theſe Yecco and Japan form another land, whoſe direction is alſo north and ſouth, over an extent of upwards of 400 miles, between the Great Sea, and that of Corea, the chains of mountains of Yeco, and of that part of Japan, cannot fail then of being directed from north to ſouth, ſince theſe lands, which are 400 leagues long in this direction, are no more than 50, 60, or 100 broad in the other from eaſt to weſt. Therefore the lands of Kamtſchatka, Yeco, and the eaſtern part of Japan, muſt be regarded as contiguous, and directed north and ſouth. Still purſuing the ſame direction after having paſſed Cape Ava at Japan, we meet with the iſland of Barnevel, and three other iſlands, which are placed one on the other exactly in the direction of north and ſouth, taking up in all a ſpace of about 100 miles. We afterwards meet with three other iſlands in the ſame direction, called the *iſlands of Callmos*, all three

placed one above the other in the ſame direction of north and ſouth. After theſe we meet with the Ladrone iſlands, fourteen or fifteen in number, all placed one above another in the ſame direction of north and ſouth, and all together occupying (including the Callanos iſlands, a ſpace more than 300 miles long, in this direction of north and ſouth, by ſo trifling a breadth, that in its greateſt parts, theſe iſlands are not ſeven or eight miles over: it therefore appears to me that Kamtſchatka, Yeco, Eaſtern Japan, the iſlands Barnevel, Prince, Callanos, and Ladrone, are only the ſame chain of mountains, and the remains of the old country which the ocean has countries in fact are only mountains, and theſe iſlands the points of mountains; the lower lands have been by degrees waſhed away and ſubmerged. All theſe ſubmerged by the ocean, and if what is related in the inſtructive letters are true, and that in fact a quantity of iſlands have been diſcovered called the *new Phillipine Iſlands*, and that their poſition is really ſuch as is given by Father Gobien, we cannot doubt but that the moſt eaſtern of theſe iſlands are a continuation of the chain of mountains, which forms the Ladrones: for theſe eleven eaſtern iſlands are all placed one above the other in the ſame direction of north and ſouth, occupying a ſpace more than 200 miles in length, the broadeſt of which is not more than ſeven or eight miles over in the direction of eaſt and weſt.

But if theſe conjectures are thought too preſumptuous, and oppoſe to my opinion the great intervals between the adjacent iſlands of Cape Ava, Japan, and Callanos, and between theſe iſlands and thoſe of Ladrone, and the new Philippine, the firſt of which is in fact about 160 miles, the ſecond 50 or 60, and the third near 120; I ſhall anſwer that the chains of mountains often extend much farther under the ſea, and that theſe

theſe intervals are ſmall in compariſon of the extent of land which theſe mountains in the above direction preſent, which is 1100 leagues, computing them from the interior part of that almoſt iſland Kamtſchatka. In ſhort, if we wholly reject this idea, which I have juſt propoſed on the ſubject of 500 leagues, which the ocean muſt have gained on the eaſtern coaſts of the continent, and on that ſuite of mountains which paſs by the Ladrone iſlands; there is at leaſt no perſon but will allow me that Kamtſchatka, Yeco, Japan, the iſlands Bongo, Tanaxima, thoſe of Great Lequeo, King's Iſland, Formoſa, Vaif, Baſhe, Babuyanes, the great iſland Lucon, the other Philippines, Mindanao, Gilolo, &c. and laſt of all New Guinea, which extends as far as New Brittany, ſituate under the ſame meridian as Kamtſchatka, do not form a continuation of land of more than 2000 leagues, interrupted only by ſmall intervals, the greateſt of which perhaps is no more than 20 leagues, ſo that the ocean forms in the lands of the eaſtern continent a very great gulph which commences at Kamtſchatka, and ends at New Britain: that this gulph is ſtrewed with iſlands, that it is ſhaped like all other excavations which the ſea might make, by continually acting againſt ſhores, &c. and that conſequently we may conjecture with ſome probability, that the ocean by its conſtant motion from eaſt to weſt, has by degrees acquired this extent on the eaſtern continent, and that it has beſides formed the mediterranean ſea of Kamtſchatka, Corea, China, and perhaps all the Archipelago, for the earth and ſea are there ſo blended that it evidently appears to be an inundated country; of which we at preſent only ſee the eminences and high lands, while the lower are hid under the waters: this ſea alſo is not ſo deep as other ſeas, and the innumerable iſlands we meet with there, are almoſt all mountains.

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If we now particularly examine all these seas, beginning at the strait of the sea of Corea towards that of China, we shall find this sea of China, forms a very deep gulf in its northern part; which commences at the island of Fungma, and terminates at the frontier of the province of Pekin, at about 40 or 50 leagues distance from that capital of the Chinese empire. This gulf in its most inner and narrowest part, is called the *Gulf of Changi*: it is very probable that this gulf, and a part of the sea of China, have been formed by the ocean, which has submerged all the flat country of this continent, of which only the highlands before-mentioned are now to be seen. In this southern part are the gulfs of Tunquin and Siam, near which is the almost island of Malayo formed by a long chain of mountains, whose direction is from north to south, and the Andaman islands, which are another chain of mountains in the same direction, and which appear to be only a succession of the mountains of Sumatra.

The ocean afterwards forms a great gulf, called the *Gulf of Bengal*, in which we may remark that the almost island of India, forms a concave curb towards the east, nearly as the great gulf of the eastern continent, which seems to have been also produced by the same motion of the ocean from east to west; in this almost island are the mountains of gates, which have a direction from north to south, as far as cape Comorin, the island Ceylon seems to have been seperated from it, and to have formerly made part of that continent. The Maldivian islands are only another chain of mountains, whose direction is also the same. After this follows the Arabian sea, which is a very great gulf, and sends out four arms into the country, the two greatest on the western side, and the two least on the east; the first of these arms on the eastern side, is the small gulph of Cambay, which is not above fifty or 60 leagues deep, and which receives

ceives two very conſiderable rivers, viz. the river Tapti, and the river Baroch, which Pietro dell Valle calls the *Mehi*; the ſecond arm towards the eaſt is famous for the velocity and height of its tides, which are greater than in any other part of the world; ſo that this arm, or ſmall gulph, is only land, ſometimes covered with water by the flux, and left bare by the reflux, which extends for more than fifty leagues. Many great rivers fall into this ſpot, as the Indus, the Padar, &c. which have brought a great quantity of earth and mud to their mouths, which by degrees raiſes the ground of the gulph, the inclination of which is ſo gentle, that the tide extends to an extreme diſtance. The firſt arm of the Arabian gulf towards the weſt, is the Perſian gulf, which is more than 250 leagues in extent in land, and the ſecond is the Red Sea, which is more than 680, computing it from the iſland Socotra; theſe two arms muſt be regarded as two Mediterranean ſeas, taking them from beyond the ſtraits of Ormuz and Babelmandel; and although they are both ſubject to a great flux and reflux, and conſequently participate of the motions of the ocean, it is by reaſon they are not far diſtant from the equator, where the motion of the tides is much greater than in any other climate, and that as they are both very long and narrow, the motion of the tides is much more violent in the Red Sea than in the Perſian Gulph; becauſe the Red Sea, which is near three times longer, and at moſt as narrow as the Perſian Gulph, does not receive any river whoſe motion might oppoſe that of the flux, whereas the Perſian gulf receives very conſiderable ones, in its moſt projecting extremity inland. It appears, therefore in this place very apparently, that the Red Sea has been formed by an eruption of the ocean; for if we examine the bearing of the lands above, and below the opening which ſerves it for a paſſage, we ſhall find that this paſſage is only a cut, and that both

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on one and the other ſide the coaſts follow the ſame direction, the Arabian coaſt from Cape Rozalgat, to Cape Fartaque, being in the ſame direction as the African coaſt, from the Cape Guardafer to Cape Sands.

At the extremity of the Red Sea is that famous neck of land called the *Iſthmus of Suez*, which forms a barrier to the Red ſea, and prevents the communication of the ſeas. In the preceding diſcourſe we have obſerved the reaſon which might incline us to think that the Red Sea is higher than the Mediterranean, and that if the Iſthmus of Suez was cut, an inundation and an augmentation of the Mediterranean might enſue. To what we have already ſaid we ſhall ſubjoin, that if even it ſhould not be agreed upon that the Red Sea was higher than the Mediterranean, it cannot be denied that there is neither flux nor reflux in that part of the Mediterranean, adjoining to the mouths of the Nile, and that on the contrary there is in the Red Sea a very conſiderable flux and reflux, which raiſes the water ſeveral feet, and which alone would ſuffice to ſend a quantity of water into the Mediterranean, if the Iſthmus was broken. Beſides we have an example on this ſubject quoted by Varenius, who proves that the ſeas are not of an equal height throughout: he ſays as follows page 100 of his Geography: "Oceanus Germanicus, qui eſt "Atlantici pars, inter Friſiam & Hollandium, ſe effundens, efficit ſinum qui, etſi parvis ſit reſpectu celebrium ſinuum maris, tamen & ipſe dicitur mare, "aluitque Hollandiæ emporium celeberrimum, Amſtelodanum. Non procul indé abeſt lacus Harlemenſis qui etiam mare Harlemenſe dicitur. Hujus altitudo non eſt minor altitudine ſinus illius Belgici, quem "diximus, & mittit ramum ad urbem Leidam, ubi in "varias foſſas divaricatur. Quoniam itaque nec lacus "hic, neque ſinus ille, Hallandici maris inundant adjacentes agros (de naturali conſtitutione loquor, non

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"ubi tempestatibus urgenter, propter quas aggeres facti "sunt) patet inde quod non sint altiores quam agri "Hollandiæ. At vero Oceanum Germanicum esse "altiorem quam terras hasce experti sunt Leidenses, "cum suscepiscent fossam seu alveum ex urbe sua ad "Oceani Germanici litora, prope Cattorum vicum "perducere (distantia est duorum milliarum) ut "recepto per alveum hunc mari possent navigationem "instituere in Oceanum Germanicum; & hinc in varias terræ regiones. Verum enimvero cum magnam "jam alvei partem perfecissent, desistere coacti sunt, "quoniam tum demum per observationem cognitum "est Oceani Germanici aquam esse altiorem quam "agrum inter Leidam & litus Oceani illius; unde locus ille, ubi fodere desierunt, dicitur *Het malle Gat.* "Oceanus itaque Germanicus est aliquantum altior "quam snus ille, Hollandicus," &c. Therefore it may be supposed that the Mediterranean is lower than the Red Sea, as the German Sea is higher than that of Holland. Some antient authors, as Herodotus and Diodorus Siculus, speaks of a canal of a communication of the Nile and Mediterranean with the Red Sea, and lastly. M. Delisle has given a map in 1704, in which he traces one end of the canal, which issues from the most eastern part of the Nile, and which he judges to be a part of that which formerly formed this communication of the Nile with the Red Sea. (See Mem. de l'Acad. Sciences 1734.)

In the third part of the book entitled, "Connoissance de l' ancien Monde, or the Knowledge of the Old World," printed in 1707, we meet with the like sentiment, and it is there said from Didodorus Siculus, that it was Nero, King of Egypt, who began this canal, that Darius, king of Persia continued it, and that Ptolemy II. finished it, and conducted it as far as the city Arsine, and that he had caused it to be opened and shut when he had found it needful. Without desiring to deny these circumstances, I am obliged to

to avow that they appear doubtful to me, and I do not know whether the violence and height of the tide in the Red Sea, would not be neceſſarily communicated to this canal; it appears to me at leaſt, that it would have required great precautions to confine the waters to avoid inundations, and a great deal of care to preſerve this canal in good repair, though hiſtorians who aſſert that this canal has been undertaken and finiſhed, do not tell us, that it endured, and the remains which are pretended to be even now perceptible, are perhaps all what has been ever done of it. The name of the *Red Sea* has been given to this arm of the ocean, becauſe that in fact it has that colour, in every part where madrapores are met with at the bottom. Let us relate what is mentioned in the "Hiſtoire general des Voyages, Vol. 1, pages 198 and 199." Before he quitted the Red Sea, D. Jean examined what might have been the reaſon why that name was given by the antients to it. and if in fact this ſea differed from others in its colour. He obſerves, that Pliny mentions ſeveral opinions on the origin of this name. Some derive it from a king named *Erythos*, who reigned in thoſe parts, and whoſe name in Greek ſignifies *Red*. Others have imagined, that the reflexion of the ſun produced a reddiſh colour on the ſurface of the water, and others that the water of the gulf had naturally this colour. The Portugueſe, who had then made ſeveral voyages to the entrance of the ſtraits, aſſert, that all the coaſt of Arabia being very red, the ſand and duſt which are detached therefrom, and which the wind carries into the ſea, tinges the water of the ſame colour.

D. Jean, who, to verify theſe opinions, did not ceaſe day nor night from his departure from Socotra, to obſerve the nature of the water, and the qualities of the coaſts as far as Suez, aſſerts, that far from being naturally red, the water is of the ſame colour as in other ſeas, and that the ſand and the duſt having nothing

nothing red likewiſe, does not give this tinge to the water. The earth of both countries is generally brown, and even black in ſome places; in others it is white; but, on the coaſts where the Portugueſe had not penetrated: he in fact ſaw three mountains ſtreaked with red of a very hard rock, and the neighbouring country of the common colour.

The truth therefore is, that this ſea from its entrance to the bottom of the gulf, is throughout of an uniform colour, which is eaſy to be demonſtrated; but it muſt alſo be owned, that in ſome parts it appeared red through chance, and in others green and white, the explanation of which phenomena is as follows. From Suaguen to Koſſir, i. e. for the ſpace of 136 leagues, the ſea is filled with ſhoals and rocks of coral; this name is given to them, by reaſon that their form and colour renders them ſo extremely like coral, that it requires great circumſpection not to be deceived. They grow like trees, and their branches take the ſame form as thoſe of coral; we diſtinguiſhed two ſorts of them, the one white, and the other red; in many parts they are covered with a kind of gum, or green glue, and in others with a deep orange. Now the water of this ſea being more tranſparent than any other in the world, ſo that the bottom may be ſeen at 20 fathom deep, eſpecially from Sanquen to the extremity of the gulf, it appears therefore to take the colour of the matters it contains; as for example; when the rocks are ſo covered with a green glue, the water which paſſes over it appears of a deeper green than the rocks themſelves, and when the bottom is only ſand, the water appears white: ſo likewiſe when the rocks are coral, in the ſenſe which I give the term, the glue which ſurrounds them is red or reddiſh, the water tinges, or rather ſeems to be tinged red: therefore as theſe coloured rocks are more frequently met with there than any

other, D'John concludes that the name of the *Red Sea* has been affixed to the Arabian gulf in preference to the *Green* or *White Sea* : he applauds himſelf on this diſcovery with ſo much the more reaſon, as the method by which he aſcertained himſelf of it, left him no kind of doubt. He cauſed a float to be moored againſt the rocks in the parts which were not deep enough to permit veſſels to approach them, and the ſailors could often execute his orders with facility, without the ſea being higher than the ſtomach at more than half a mile from the rocks. The greateſt part of the ſtones and flints they drew up, in thoſe parts where the water appeared red, was alſo of that colour : in the water which appeared green, the ſtones were green, and if the water appeared white, the bottom was white ſand, without any other mixture."

I well know that ſome have have pretended, that there was a double current in the ſtrait of Gibraltar, the one ſuperior which carried the water of the ocean into the Mediterranean, and the other inferior, whoſe effect, ſay they, is contrary ; but this opinion is evidently falſe, and contrary to the laws of hydroſtatics : ſo it has likewiſe been aſſerted, that there are inferior currents in many other places, the direction of which was oppoſite to that of the ſuperior current ; as in the Boſphorus, the ſtrait of ſand, &c. and Marſili relates even experiments made in the Boſphorus, which proves this circumſtance ; but there is a great appearance that the experiments have been badly made, ſince the matter is impoſſible, and repugnant to all the notions we have on the motions of the waters ; beſides Greaves in his pyramidography, page 101 and 102, proves by well-made experiments, that there is no inferior current in the Boſphorus, whoſe direction is oppoſite to the ſuperior : what may have deceived Marſili and others, is, that in the Boſphorus, as well as in the ſtrait of Gibraltar,

Gibraltar, and in all rivers which flow with ſome rapidity, there is a conſiderable eddy along the ſhores, the direction of which is generally different, and ſometimes quite contrary to the principal current of the waters.

Let us now trace all the coaſts of the new continent, from the Cape *Holdwith-Hope*, lying in the 73d degree, north latitude, which is the moſt northern land we are acquainted with in New Greenland, and is not above 160 or 180 miles diſtant from Lapland. From this cape we may follow the coaſt of Greenland, as far as the polar circle, where the ocean forms a broad ſtrait between Iceland and Greenland. It is pretended that this country adjacent to Iceland is not the ancient Greenland which the Danes formerly poſſeſſed as a province dependant on their kingdom. In antient Greenland there were civilized people and chriſtians, biſhops, churches, and towns conſiderable by their commerce. The Danes alſo viſited it frequently, and as eaſily as the Spaniards can go to the Canaries: there ſtill exiſts, as is aſſerted, titles and ordinances for the affairs of this country, all which are not very antient: nevertheleſs, without our being able to devine why, this country is abſolutely loſt not the leaſt trace of what we have related is to be met with, nor in new Greenland, the people are wild and ſavage, there is no veſtiges of any edifice, not a word of their language, which has an affinity with the Daniſh; in ſhort, there is nothing which might give us room to judge that this is the ſame country, it is even almoſt deſerted, and ſurrounded with ice for the greateſt part of the year: but as theſe lands are of a vaſt extent, and the coaſts but little frequented by modern navigators, who may have miſſed the ſpot where the deſcendants of theſe poliſhed people may inhabit, or that the ice having become more abundant in this ſea, prevents any one at preſent from

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approaching near the ſhore in this place; nevertheleſs this whole country, to judge of it by the maps, has been coaſted and diſcovered: it forms nearly a great iſland, at the extremity of which are the two ſtraits of Forbiſhers and the iſland of Frieſland, where it is extremely cold, although they are not higher than the Orcades, that is, at 60 degrees.

Between the weſtern coaſt of Greenland, and that of Labrador, the ocean forms a gulf, and afterwards a large Mediterranean Sea, the coldeſt of all ſeas, the coaſts of which are not as yet perfectly known. By following this tract due north, we come to the large ſtrait of Davis, which leads to the Chriſtian Sea, terminated by Baffin's Bay, which forms a kind of road from which there is no appearance of getting out but by falling into another road of the ſame nature, i. e. Hudſon's Bay. Cumberland Strait, which as well as Davis's, may lead to the Chriſtian Sea, is narrower, and more liable to be frozen: that of Hudſon though much more to the ſouth, is alſo frozen during one part of the year, and a very ſtrong motion of flux and reflux has been remarked in theſe ſtraits and Mediterranean ſeas, quite contrary to that which comes into the Mediterranean ſeas of Europe, whether the Mediterranean or Baltic, where there is no flux or reflux, which can proceed only from the difference of the ſeas motion, which always moving from eaſt to weſt, occaſions high tides in the Straits, oppoſite to this moving direction, that is to ſay, in the Straits, whoſe openings are turned towards the eaſt, whereas in thoſe of Europe which preſent their opening to the weſt, there is no motion; the ocean by its motion enters into the firſt, and avoids the laſt; and this is the reaſon that there are ſuch violent tides in the ſeas of China, Corea, and Kamtſchatka.

By deſcending from Hudſon's ſtrait towards Labrador, we ſee a narrow opening, in which Davis in 1586, ſailed as far up as 30 leagues, and trafficked a little

little with the inhabitants, but no one that I know of, has ſince attempted the diſcovery of this arm of the ſea, and we only are acquainted with the country of the Eſkimaux of all the adjacent land. The fort Pon Chartrain is the only and the moſt northern habitation of all this country, which is only ſeparated by the iſlands of Terra Nova by the little ſtrait of Belliſle, which is not much frequented; and as the eaſtern coaſt of Terra Nova is in the ſame direction as the coaſt of Labrador, we muſt regard the iſland of Terra Nova as a part of the continent, the ſame as royal iſland appears to be a part of the continent of Acadia. The great bank, and the other banks on which the cod is caught, are not ſhallow, as might be imagined; they are of a conſiderable depth, and produce very violent currents. Between Cape Breton and Terra Nova is a very broad ſtrait, by which we enter a ſmall Mediterranean Sea, called the Gulf of St. Laurence; this ſmall ſea has an arm which extends far into land, and ſeems to be only the mouth of the river St. Laurence: the motion of flux and reflux is extremely ſenſible in this arm of the ſea, and even at Quebec, which projects more into the land, the waters riſe ſeveral feet high. On quitting the gulph of Canada, and following the coaſt of Acadia, we meet with a ſmall gulph called the bay of Boſton, which forms a ſmall ſquare inlet into the land. But before we trace this coaſt farther, it is juſt to obſerve, that from Terra Nova as far as the moſt projecting Antille iſlands, as Barbadoes and Antigua, and even as far as Guiana, the ocean forms a very great gulf, which reaches for 500 leagues as far as Florida. This gulf of the new continent is ſimilar to that of the old, of which we have taken notice, and ſo likewiſe in the eaſtern continent the ocean, after having made a gulph between Kamtſchatka and New Britain, afterwards forms a vaſt Mediterranean Sea, which comprehends

hends the ſea of Kamtſchatka, Corea, China, &c. In the new continent the ocean, after having formed a great gulf between Terra Nova and Guiana, forms a very large Mediterranean ſea, reaching from the Antilles to Mexico, which confirms our obſervations on the ſubject of the effects of the motion of the ocean from eaſt to weſt, for it appears that the ocean has gained on the eaſtern coaſts of Aſia, and thoſe two great gulfs, which the ocean has formed in thoſe two continents are under the ſame degree of latitude, and nearly of the ſame extent, which forms relations or ſimilar connections, appearing to proceed from the ſame cauſe.

If we examine the poſition of the Antilles, beginning at Trinity iſland, which is the moſt ſouthern, we cannot doubt but that the iſlands of Trinity, Tobago, Grenade, the Grenadilles, St. Vincent, Martinico, Maria Galand, Deſirado, Antigua, and Barbadoes, with every other iſland which accompany them, form a chain of mountains, whoſe direction is from ſouth to north, like that of the iſland of Terra Nova, and the Eſkimaux. Afterwards the direction of the Antilles is from eaſt to weſt, beginning at the iſland of Barbadoes, then paſſing by St. Bartholomew, Porto Rico, Domingo, and Cuba, nearly as Cape Bretton, Acadia, and New England. All theſe iſlands are ſo adjacent to each other, that they may be looked upon as an interrupted tract of land, and as the ſummit of an overflown or ſubmerged land. Moſt of theſe iſlands in fact are only points of mountains, and the ſea which ſurrounds them is a real Mediterranean, where the motion of flux and reflux is ſcarcely more ſenſible than in our Mediterranean ſea, although the openings which they preſent to the ocean, are directly oppoſite to the motion of the waters from eaſt to weſt, which muſt contribute to render this motion felt in the gulf of Mexico, but as this ſea is very broad, the flux and reflux communicated to it by

by the ocean, diſperſing itſelf over ſo large a ſpace, loſes a great part of its rapidity, and becomes almoſt inſenſible, at the coaſt of Louiſania, and many other places.

The old and new continent appear therefore both to have been waſhed away by the ocean, to the ſame height and ſame depth; both have afterwards formed a vaſt Mediterranean Sea, and a great quantity of iſlands which are ſituated nearly on the ſame height; the only difference is, that the old continent being much broader than the new, there is in the weſtern part of it a weſt Mediterranean ſea, which cannot be found in the new, but it appears that all which has happened to the eaſtern countries of the old world has alſo happened to the eaſtern parts of the new, and that the greateſt deſtruction of the lands is made nearly in their middle, and at the ſame height, becauſe in fact it is in this middle, and near the equator, where the greateſt motion of the ocean is made.

The coaſts of Guiana, comprehended between the mouth of the river Oronoko and Amazonia, preſents nothing remarkable, but this river the broadeſt in the univerſe, forms a conſiderable extent of water near Coropa, before it arrives at the ſea by two different mouths, which form the iſland of Caviana. From the mouth of the Amazon river to Cape St. Roche, the coaſt runs almoſt ſtrait from weſt to eaſt; from the Cape of St. Roch to St. Auguſtine it runs from north to ſouth, and from Cape St. Auguſtine to the Bay of All Saints, it returns towards the weſt; ſo that this part of Brazil forms a conſiderable projection in the ſea, which directly faces a like projection of land in Africa. The Bay of All Saints is a ſmall arm of the ocean, running about 50 leagues deep in land, and much frequented by navigators. From this bay to Cape St. Thomas, the coaſt runs direct from north to ſouth, and afterwards in a ſouth eaſt direction as

far

as the mouth of the river Plata, where the ſea forms a ſmall arm, which re-aſcends nearly 100 leagues in land. From thence to the extremity of America the ocean forms a great gulf, terminated by the adjacent lands of Terra del Fuega, as Falkland iſland, Cape Aſſumption, Beauchene, and the land which forms the Strait de la Roche, diſcovered in 1671: at the bottom of this gulf we meet with the Straits of Magellan, which is the longeſt of all the Straits, and where the flux and reflux is extremely ſenſible: beyond is that of de la Maire, which is ſhorter, and more convenient; and at laſt Cape Horn, which is the point of the continent of South America.

We muſt remark on the ſubject of theſe points fomed by the continent, that they are all placed in a like manner; all facing the ſouth, and moſt of them cut by the ſtraits which run from eaſt to weſt; the firſt is that of ſouth America, which faces the ſouth or the ſouthern pole, and is cut by the ſtrait of Magellan; the ſecond is that of Greenland, which alſo directly faces the ſouth, and is alſo cut from eaſt to weſt by Forbiſhers ſtraits: the third is that of Africa, which alſo faces the ſouth, and which is beyond the cape of Good Hope, has banks and great depths that appear to have been divided from it: the fourth is the point of that almoſt iſland of Indus, which is cut by a ſtrait that forms the iſland of Ceylon, and facing the ſouth like all the reſt. Hitherto we perceive no reaſon to be given for this ſingularity, nor to ſay why the points of all the large iſlands are all turned towards the ſouth, and almoſt all cut at their extremities by ſtraits.

By aſcending from Terra del Fuega along the weſtern coaſt of South America, the ocean very conſiderably penetrates into the land: and this coaſt ſeems exactly to follow the direction of the lofty mountains which croſs all South America, from ſouth to north, from the equator to Terra del Fuega.

Near

Near the equator the Ocean forms a pretty considerable gulph, beginning at Cape St. Francois, and reaching as far as Panama, where is the famous isthmus, which like that of Suez, prevents the communication of the two seas, and without which there would be an entire separation of the old and new Continent, from thence there is nothing remarkable as far as California, which is a very long peninsula. In short, the western coasts of California, have been followed from California, to the 43d degree, at which latitude, Drake, who was the first that made the discovery of the land to the north of California, and who has called it New Albion, was obliged through excessive cold, to change his course and to anchor in a small bay which bears his name, so that the seas of these climates have not been discovered beyond the 43d and 44th degree, no more than the lands of North America, the last of which that are known, are the Moozoemki, under the 48th degree and the Assiniboils under the 51st, the first are much nearer the west than the last. All beyond that, whether land or sea, throughout an extent of more than 1000 leagues in length and as many in breadth is unknown.

The ocean therefore surrounds the whole earth without any interruption of continuity, and the tour of the globe may be made by passing the point of South America, but it is not yet known whether the ocean surrounds the northern part of the globe in the like manner, and all mariners who have attempted to go from Europe to China by the north east or north west have alike miscarried in their enterprises.

The lakes differ from the Mediterranean seas, because they do not receive any water from the ocean, and that on the contrary, if they have communication with the seas, they furnish them with water, thus the Black Sea which some geographers have

regarded as a connection with the Mediterranean and consequently as an appendix of the ocean, is only a lake; because, in place of receiving water from the Mediterranean, it supplies it with some, and flows with rapidity through the Bosphorus into the lake called the sea of Mamora, and from thence through the strait of the Dardanelles into the Grecian sea. The Black Sea is about 250 leagues long by 100 broad and it receives a great number of rivers the most considerable of which are, the Danube, the Nieper, the Don, the Boh, the Donjec, &c. The Don which unites with the Donjec, forms before it arrives at the Black Sea, a lake or a very considerable morass, called the *Palus Meotide*, the extent of which is more than 100 leagues in length by 20 or 25 broad. The sea of Marmora, which is below the Black Sea, is a smaller lake that the Palus Meotide, being no more than 50 leagues long by 8 or 9 broad.

Some ancients, and among the rest Diodorus Siculus, have written that the Pont Euxine, or the Black Sea, was formerly only a large river or lake which had no communication with the Grecian sea; but that this great lake being considerably increased with time by the water of the rivers which arrive there, it at length opened itself a passage, at first on the side of the Cyanean islands, and afterwards on the side of the Hellespont. This opinion appears to be very probable, and the circumstance is indeed easily explained, for, by supposing that the bottom of the Black Sea was formerly lower than the river is at present, we shall readily perceive that the rivers which come into it, will have raised the bottom of this sea by the mud and sand which they brought with them, and that consequently it may have happened that the surface of this sea was sufficiently elevated for the water to force itself a vent; and

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as the rivers ſtill continue to bring ſand and earth, and at the ſame time the quantity of water diminiſh the rivers, in proportion as the mountains from which they drew their ſources, ſink lower, it may happen in a courſe of years that the Boſphorus will be filled : but as theſe effects depend on many cauſes, it is ſcarcely poſſible to give any other than mere conjectures thereon. From this teſtimony of the ancients, Mr. Tournefort in his voyage to the Levant, ſays, that the Black Sea receiving the waters of a great part of Europe and Aſia, after being conſiderably increaſed, opens itſelf a paſſage by the Boſphorus and afterwards forms the Mediterranean, or ſo conſiderably augments it, that from a lake which it formerly was, it became a great ſea, which afterwards opened itſelf a road through the ſtrait of Gibraltar, and that probably this was the time that the Atlantic iſland mentioned by Plato was ſubmerged. This opinion has no foundation, ſince we are certain that it is the ocean which flows into the Mediterranean and not the Mediterranean into the ocean. Beſides, M. Tournefort has not combined two eſſential circumſtances, both of which, nevertheleſs, he relates; the firſt, which is that the Black Sea received nine or ten rivers, not one of which but ſupplies it with more water than it throws out : the ſecond, is, that the Mediterranean does not receive more water from the rivers than the Black Sea, although it is ſeven or eight times larger, and that what the Boſphorus ſupplies it with does not make the tenth part of what falls into the Black Sea : how then can he ſuppoſe that this tenth part of what falls into a ſmall ſea, has formed not only a large ſea, but has alſo ſo greatly increaſed the quantity of water, as to have broken down the lands at the ſtrait, and ſubmerge an iſland larger than Europe ? It is eaſy to perceive that this paſſage of M. Tournefort has not

not had due reflection. The Mediterranean on the contrary, receives at least ten times more water from the Ocean, than from the Black Sea, because the Bosphorus is only 800 feet broad in its narrowest part, whereas the strait of Gibraltar is more than 5000, and that even by supposing them equal, that of Gibraltar is by far the deepest.

M. de Tournefort who ridicules Polybius on his opinion that the Bosphorus fills itself, and treats it as a false prediction, did not pay sufficient attention to circumstances, when he asserted the event to be impossible. This sea which receives eight or ten great rivers, most of which bring with them much earth, sand and mud, does it not gradually choak itself up? The winds and the natural current of the waters towards the Bosphorus, must not they convey thither a part of their earths? it is on the contrary, therefore, very probable that by a course of time the Bosphorus will be filled, when the rivers which comes into the Black Sea shall be greatly diminished: now all rivers daily diminish, because mountains daily grow lower, the vapours which hang round the mountains being the first sources of rivers, their size and quantity of water depends on the quantity of those vapours, which cannot fail of diminishing as the mountains diminish in height.

This sea in fact receives more water from rivers than the Mediterranean, and the same author writes as follows "the whole world knows that the great- "est waters of Europe falls into the Black Sea, by "means of the Danube, in which the rivers of "Suabia, Franconia, Bavaria, Austria, Hungary, "Moravia, Carinthia, Croatia, Bothnia, Servia, "Transilvania, Valachio, empty themselves: those "of Black Russia and Podolia go into the same "sea by the Niester; those of the southern and "eastern parts of Poland, North Muscovy, and

"the

" the country of the Cossacks enter therein by the
" Neiper or the Boristhenes; the Tanais and Copa
" arrive also in the Black Sea by the Crimarian
" Bosphorus; the rivers of Mingrelia, of which
" Pharus is the principal, also voids itself into
" the Black Sea, as does the Casalmar, the Sangaris
" and other rivers of Asia Minor which have their
" course towards the north, nevertheless the Thra-
" cian Bosphorus is not comparable to any of these
" great rivers." See Tournefort.

All this proves that evaporation alone is sufficient to raise a very considerable quantity of water, and it is from this great evaporation from the Mediterranean that the ocean continually flows thither through the strait of Gibraltar. It is very difficult to estimate the quantity of water one sea receives; we should be acquainted with the breadth, the depth and rapidity of all the rivers which enter therein, to know how much they increase and diminish in the different seasons of the year, and when even all these circumstances should be acquired, the most important and difficult still remains, which is, to know how much this sea loses by evaporation; for, by supposing it even proportional to the surfaces, we clearly see that it must be more considerable in a hot than in a cold climate; besides the water mixed with salt and bitumen evaporates more slowly than fresh water; a troubled sea sooner than one that is tranquil, and the difference of depth is also of great effect: so that there enters so many elements into this theory of evaporation, that it is scarcely possible to calculate any exact estimations on this point.

The water of the Black Sea appears to be less clear and much less saline than that of the Ocean. No island is to be met with throughout this sea, tempests are very violent here and more dangerous than in the Ocean; because the whole body of the waters being

being contained in a bason, which may be said to have no outlet, they have a kind of whirling motion, when they are agitated, which strikes the vessels on every side with an insupportable violence. See Chardin's Travels.

Next to the Black Sea the greatest lake in the universe is the Caspian sea, whose extent in length from north to south is about 300 leagues, and scarcely more than fifty broad, computing it in a moderate proportion. This lake receives one of the greatest rivers in the world, i. e. the Volga and some other considerable rivers, as the Kier, the Fay, and the Gempo; but what is singular, is, that it does not receive any on its eastern side throughout this whole length of 300 leagues. The country which borders it on that side, being only a desert of sand, which no one yet has travelled over. Czar Peter the 1st, having sent some engineers there to design a chart of the Caspian sea, discovered that the figure of this sea was quite different from that given to it in geographical charts, it is represented round, though it is very long and narrow. The eastern coasts of this sea are therefore not known, no more than the neighbouring country: we are unacquainted as far as the existence of lake Aral; which is 100 leagues distant from it towards the east, or if we were acquainted with some of these coasts of lake Aral, it was thought to be a part of the Caspian sea, so that before the discoveries of the Czar, there was land in this climate upwards of 300 leagues long by 100 and 150 broad which was then unknown. Lake Aral in nearly an oblong, and may be 90 or 100 leagues long, by 50 or 60 broad; it receives two very considerable rivers, the Siaderoacias and the Oxus, but there is no outlet to the lake, no more than to the Caspian sea.

Like

Like the Caſpian ſea too, which receives no river on the eaſtern ſide, ſo the lake Aral receives none on the weſt, which muſt incline us to preſume, that formerly theſe two lakes formed only one, and that the rivers having by degrees diminiſhed and left a very great quantity of ſand and mud, the country which now divides them, was formed of ſuch matters. There are ſome ſmall iſlands in the Caſpian ſea, and its waters are much leſs ſaline than thoſe of the ocean; ſtorms are here very dangerous, and large veſſels are not uſed for navigation therein, as it is ſhallow, and many banks and ſhoals are ſcattered under the ſurface of the water. Pietro della Valle, writes as follows, " The largeſt veſſels ſeen on the Caſpian ſea, along the coaſts of Mazand Perſia, where the town of Ferhabad ſtands; although they are called ſhips, they appear to me to be ſmaller than our Tartanes. They are very high decked, and draw but little water, having a flat bottom. They give this form to their veſſels likewiſe, not only becauſe the Caſpian ſea is ſhallow, but becauſe it is filled with ſand banks and the water is very low in ſome places; ſo that if the veſſels were not fabricated in this manner, they could not be uſed in that ſea. Indeed, I am aſtoniſhed, and not without foundation I preſume, why at Ferhabad they fiſh only for ſalmon, which are found at the mouth of the river, and for ſome poor ſturgeons and many other ſort of fiſh, natives of freſh waters, and which are of little value: and as I attribute the cauſe of it to their ignorance of the arts of navigation and fiſhing, or to the fear of loſing themſelves if they fiſhed in the open ſea. The Cham of Eſterabad whoſe reſidence is at a ſea port, and to whom conſequently the reaſons are not unknown, by the experience he had gained, gave me one reaſon, viz. That the waters are ſo ſhallow 20 and 30 miles at ſea that it is impoſſible

ble to caſt their nets therein, or to take any fiſh which might be of the conſequence of our Tartanes, ſo that it is for this reaſon they give the abovementioned form to their veſſels, which are not mounted with any cannon, as but few Corſairs and Pirates viſit this ſea.

Struys and other travellers have aſſerted, that in the neighbourhood of Cilam, there was two gulphs wherein the waters of the Caſpian ſea were inguſphed, to proceed afterwards by ſubterranean canals into the Perſian gulph. De Fer and other geographers have even marked out theſe gulphs in their maps, nevertheleſs theſe gulphs do not exiſt, the people ſent by the Czar being aſſured of the contrary (See Mem. Acad. Sciences 1721.) The circumſtance of willow leaves being ſeen in great quantity on the Perſian gulph, and which are ſuppoſed to come from the Caſpian ſea; becauſe there are no ſuch trees on the Perſian gulph, being advanced by the ſame authors, is alſo as fictitious as the gulphs, and Gameli Careri, as well as the Muſcovites, aſſert that theſe gulphs are only imaginary: in fact, if we compare the extent of the Caſpian ſea with that of the Black ſea, we ſhall find that the firſt is near one third ſmaller than the ſecond: that the Black ſea receives much more water than the Caſpian: the evaporation is ſufficient to carry off all the water which falls into theſe two lakes, and that it is no ways neceſſary to ſuppoſe gulphs in the Caſpian ſea, no more than in the Black ſea.

There are lakes which like pools, do not receive any river, and from which none go out. There are others which do receive rivers, and from which others run; and at laſt, ſome which only receive rivers, The Caſpian ſea and the lake Aral are of the laſt kind, they receive the waters of many rivers and contain them. Thus the Dead ſea receives the Jordan, though

continually reſtores it, although, in fact, it is ſtronger during the intumeſcence and weaker during the detumeſcence, from the above reaſon.

The principal circumſtances of this motion are, 1. That it is more ſenſible when the moon is new, or at the full, than in the quadratures: in ſpring and in autumn, it is alſo more violent than at any other time of the year, and it is weaker in the ſolſtices, which is very naturally explained by the combination of the powers of the attraction of the moon and ſun. (See Newton's Demonſtrations.) 2. The wind often alters the direction and quantity of this motion, particularly the wind which conſtantly blows from the ſame quarter. It is the ſame with reſpect to large rivers, which convey their waters into the ſea, and produce a current there often extending ſeveral leagues, when the direction of the wind agrees with the general motion, like that from eaſt to weſt, it becomes more ſenſible: of this we have an example in the Pacific ocean, where the motion from eaſt to weſt is conſtant and very perceptible. 3. We muſt remark that when one part of a fluid moves, the whole maſs is likewiſe moved: now in the motion of the tides, there is a very great part of the ocean which moves in a very ſenſible manner: the whole maſs of the ſea therefore moves at the ſame time and the ſeas are agitated by this motion throughout their whole extent and length.

To underſtand this rightly, we muſt attend to the nature of the power which produces the flux and reflux, and reflect on its actions and effects. We have obſerved that the moon acts upon the earth by a power called *attraction*, and by others *gravity*, this power penetrates through the globe of earth, and is exactly proportional to the quantity of matter and at the ſame time decreaſes as the ſquare of the diſtance increaſes: this poſition made, let us examine what muſt happen by ſuppoſing the moon at

the meridian of one part of the ſea. The ſurface of the waters being immediately under the moon, is then nearer that planet than any other part of the globe; hence this part of the ſea muſt be elevated towards the moon, by forming an eminence the ſummit of which correſponds to the center of this planet: for the formation of this eminence, it is neceſſary that the water, as well of the ſurrounding ſurface at the bottom of the ſea contributes thereto; which they in fact do, in proportion of the proximity they are in of the planet which performs this action in the inverted ratio of the ſquare of the diſtance: thus the ſurface of that part of the ſea raiſing itſelf firſt, the water of the ſurface of the neighbouring parts will be likewiſe elevated, but to a leſs height and the water at the bottom of all theſe parts will undergo the ſame effect and will raiſe by the ſame cauſe, ſo that all this part of the ſea growing higher and forming an eminence, it is neceſſary that the water of the ſurface and of the bottom of the remote parts, and on which this force of attraction does not act, proceeds with precipitation to replace the waters which are elevated: this is what produces the flux, which is more or leſs ſenſible on different coaſts, and which, as is ſeen, agitates the ſea not only at its ſurface, but even to the greateſt depths. The reflux happens afterwards by the natural inclination of the water; when the planet has paſt and no longer uſes its power, the water which was raiſed by the action of this foreign power, retakes its level and regains the ſhores and the places which it had been forced to quit, afterwards when the moon paſſes to the meridian of the antipode of the place where we have ſuppoſed it firſt raiſed the waters to, the ſame effect enſues. The water at this inſtant, where the moon is abſent and fartheſt diſtant, ſenſibly raiſes itſelf, as much as in the time where it is pre-

present and nearest that part of the sea: in the first case, the waters rise, because they are nearer the planet than all the other parts of the globe; and, in the second case, it is from the contrary reason, they do not rise from their being more remote from it than all the other parts of the globe, and this is readily perceived must produce the same effect: for then the waters of this part being less attracted than any other part of the globe, will necessary remove farther from the rest of the globe, and form an eminence, the summit of which will answer to the point of the least action, i. e. to the point of the Heaven directly opposite to that where the moon is, or what is tantamount, to the point where it was thirteen hours before, when it had first elevated the water; for, when it is arrived at the horizon, the reflux happening, the sea is then in its natural state and the water is in an equilibrium and level. But when the moon is at the opposite meridian, this equilibrium can no longer subsist, since the waters of the part opposite to the moon being at the greatest distance possible from that planet, they are no less attracted than the remaining part of the globe, which being intermediate, is found to be nearer the moon, and hence their relative weight, which always retains them in an equilibrium and level, impels them towards the opposite point to the moon. Thus in the two cases, when the moon is at the meridian of a place, or at the opposite meridian, the water must be raised nearly to the same quantity and consequently fall and rise, likewise in the same quantity when the moon is either at the horzion, at its setting, or at its rising. We see perfectly that a motion the cause and effect of which are, such as we have just mentioned, necessarily disturbs the whole mass of the sea, and agitates it throughout its whole extent and depth: and if this motion appears insensible in the

the open ſeas and when we are diſtant from land; it is nevertheleſs no leſs real; the bottom and the ſurface are moved nearly alike and even the water at the bottom, which the winds cannot ruffle like thoſe of the ſurface, feel this action much more regularly than thoſe of the ſurface, and they have a more regular motion, always alternatively directed in the ſame manner.

From this alternative motion of flux and reflux, there reſults as we have already obſerved, a continual motion of the ſea from the eaſt towards the weſt, becauſe the planet which produces the intumeſcence of the waters, goes itſelf from eaſt to weſt and ſucceſſively acting in the ſame direction, the water follows the motion of the planet in the ſame direction. This motion of the ſea from eaſt to weſt is very ſenſible in all ſtraits; for example, at the ſtrait of Magellan, the flux raiſes the water nearly twenty feet high, and the intumeſcence endures ſix hours, whereas the reflux or detumeſcence laſts only two, (See Naſebrough's Voyage.) and the water runs towards the weſt, which evidently proves that the reflux is not equal to the flux, and that from both theſe there reſults a motion towards the weſt, much ſtronger in the time of the flux than in that of the reflux; and this is the reaſon that in the open ſeas remote from land, the tides are only felt by the general motion which reſults from them; i. e. by this motion from eaſt to weſt.

The tides are ſtronger and they ſwell and lower the waters much more conſiderably in the torrid zone between the tropics, than in the reſt of the ocean: they are alſo much more ſenſible in the parts which extend from eaſt to weſt, in gulphs which are long and narrow, and on the coaſts where there are iſles and promontaries; the greateſt known flux is, as we have obſerved in the preceding

ceding article, at one of the mouths of the river Indus, where the water riſes thirty feet: it is alſo very remarkable near Malays, in the ſtrait of Sonde, in the Red Sea, in Nelſon's Bay, at 55 degrees northern latitude, where it riſes 15 feet, at the mouth of the river St. Laurence, on the coaſts of China, Japan, Panama, in the gulph of Bengal, &c.

The motion of the ſea from eaſt to weſt is very ſenſible in ſome places, mariners have often obſerved it, in ſailing from India to Madagaſcar and in Africa: it is alſo very perceptible in the Pacific Sea, and between the Molucca's and Braſil: but the place where this motion is moſt violent, are the ſtraits which join ocean to ocean. For example, the waters of the ſea are carried with ſuch great force from eaſt to weſt by the ſtrait of Magellan, that this motion is felt even to a great diſtance in the Atlantic ocean, and it is ſuppoſed that this cauſed Magellan to conjecture that there was a ſtrait by which the two ſeas had a communication. In the Manilla ſtraits and in all the canals which divide the Maldivian iſlands, the ſea flows from eaſt to weſt, as well as in the gulph of Mexico between Cuba and Jucatan: in the gulph of Paria, this motion is ſo violent, that the ſtrait is called the *Dragon's Throat*. In the Canadian ſea, this motion is very violent, as well as in the Tartarian ſea and the ſtrait of Waigaits, through which the ocean flowing with rapidity from eaſt to weſt, conveys enormous maſſes of ice from the Tartarian ſea into the northern ſea of Europe. The Pacific ocean likewiſe flows from eaſt to weſt through the ſtraits of Japan, the ſea of Japan flows towardsChina,theIndian ocean flows towards the weſt into the ſtrait of Java and by the ſtraits of the other Indian iſlands. We cannot therefore doubt that the ſea has a conſtant and general motion from eaſt to weſt, and we are aſ-

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ſured that the Atlantic ocean flows towards America, and that the Pacific ſea goes from it, as we evidently perceive it at the Cape between Lima and Panama.

On the whole, the alternatives of the flux and reflux are regular and are made in ſix hours and a half on moſt of the ſea coaſts, though at different hours, according to the climate and poſition of the coaſts; thus the ſea coaſts are continually beaten againſt by the waves, which at each time waſh away ſome ſmall parts of matters which they tranſport far off and depoſit at the bottom; ſo likewiſe the waves convey on the lower ſhores, ſhells and ſands which remain, and which by degrees accumulate by horizontal layers, form at length downs and heights as lofty as hills, and which in fact are perfectly ſimilar, as well by their form as by their internal compoſition: thus the ſea carries many marine productions on the lower ſhores, and convey away to a diſtance all matters which it can waſh off from the high coaſts againſt which it acts, either in the time of the flux, or in ſtorms and tempeſtuous weather.

To give an idea of the efforts of a troubled ſea againſt coaſts, I think it my duty to relate a circumſtance which has been affirmed to me by a very credible perſon, and which I have the readier given credit to, as I have myſelf ſeen ſomething nearly ſimilar. In the principal iſland of the Orcades, there are coaſts compoſed of rocks perpendicularly divided to the ſurface of the ſea, ſo that by being placed on the top of theſe rocks, we may let a lead fall to the ſurface of the water, by fixing the cord to the end of a rod of nine feet. This operation which may be done when the ſea is calm, has given the meaſure of the height of the coaſt, i. e. 200 feet. The tide in this place is very conſiderable as it commonly is in all the parts where
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there are projecting lands and iſlands; but when the wind is very ſtrong, which is very common in Scotland, and the ſea at the ſame time ſwells, the motion is ſo great and the agitation ſo violent that the water riſes to the ſummit of the rocks which border the coaſt, i. e. 200 feet, where it falls in the form of rain; it even throws to this height the gravel and ſtones, which it detaches from the foot of the rocks, and ſome of theſe ſtones, by the relation of ocular teſtimony which I here quote, are broader than the hand.

I have myſelf ſeen in the part of Livonia, where the ſea is much more calm, and where there is no tide, a tempeſt in December, 1731, wherein they were obliged to cut down the maſts of ſome veſſels which were in the road, that had quitted their anchors. I have ſeen, I ſay, the ſea riſe above the fortifications, which appeared to me ſo conſiderably high above the water, and as I was on the moſt projecting, I could not regain the town without being wetted by the ſea water, much more than I could have been by the moſt plentiful rain.

Theſe examples are ſufficient to ſhew us with what great violence the ſea acts againſt the coaſts; this violent agitation deſtroys and diminiſhes by degrees the land on the coaſts; the ſea carries away all theſe matters and lets them fall as ſoon as a calm has ſucceeded the agitation. In tempeſtuous weather, the water of the ſea which is commonly the cleareſt of all waters, is troubled and mixed with the different matters which the motion of the waters detaches from the ſhore and the bottom, and the ſea then caſts on the ſhore a number of things which it brings from a diſtance, and which are never meet with but after great ſtorms; as ambergreaſe on the weſtern coaſts of Ireland, and yellow amber on thoſe of Pomerania, cocoa nuts on the coaſts of India, &c. and ſometimes pumice ſtones and

and other singular stones. We can quote on this occasion a circumstance related in the new travels to the American islands. "Being at St. Domingo, says the author, among other things they gave me some light stones, which the sea brought to the coast when there had been strong southerly winds, there was one two feet and a half long by eighteen broad, and one thick, which did not quite weigh five pounds: it was as white as snow, much harder than pumice stones, of a fine consistency, having no appearance of any porosity, but when it is thrown into water, it rebounds like a ball that is thrown on the ground: it is with difficulty sunk above half an inch;" this stone must be a very fine and close grained pumice stone, which issues from some volcano, and which the sea had conveyed, as it transports ambergrease, cocoa nuts, common pumice stone, seeds of plants, rushes, &c. on this subject we may consult Ray's discourses and observations on this kind have been generally made on the coasts of Ireland and Scotland. The sea by its general motion from east to west, must convey the productions of our coasts to those of the American's, and it is likely that by irregular motions, which we are unacquainted, that it brings the productions of the east and west Indies on our shores, as well as the productions of the north. There is a great appearance that the wind has a great share in these effects. It has often been observed in the high seas, far from shore, large spots covered with pumice stones; it cannot be supposed otherwise, than that they proceeded from the volcano's of islands or land, which the current transported to the middle of the seas. Before the southern part of Africa was known, and in the time when the Indian sea was thought to have no communication with our ocean, an index of this kind afforded the first supposition of it. The alternative motion of the flux and reflux, and the

the constant motion of the sea from east to west, presents different phænomena in different climates, according to the bearing of the land, and the height of the coasts; there are parts where the general motion from east to west, is not sensible; there are others where the sea has even a contrary motion, as on the coast of Guinea. But these motions so contrary to the general motion, are occasioned by the winds, by the position of the lands, by the waters of large rivers, and by the disposition of the bottom of the sea, all these causes produce currents which alter, and often perfectly change the general motion in many parts of the sea: but as the motion of the sea from east to west, is the greatest, most general and constant, it must also produce the greatest effects, and all taken together, the sea must in time gain ground towards the west, and leave towards the east, although it may happen that on those coasts where the winds from the east blow during the greatest part of the year, as in France, England, the ground gains towards the west, but once more, these particular exceptions do not destroy the effect of the general cause.

ARTICLE XIII.

Of the Inequalities of the bottom of the Sea and of Currents.

THE coasts of the sea may be distinguished into three kinds, 1st. the elevated or lofty coasts, which are rocks and hard stones, generally divided perpendicularly, and which rise sometimes to the height of 7 or 800 feet. 2d. The low coasts, some of which are flat, and almost of a level with the surface of the sea, and others rising with a moderate elevation, often bounded by rocks at the water's

edge, forming ſhelves, which render the approach to ſhore very difficult and dangerous. 3dly. Downs, which are coaſts formed by ſand which the ſea accumulates, or which are depoſited by rivers, theſe downs form hills more or leſs elevated according to the accumulated ſand.

The coaſts of Italy are bordered by ſeveral ſorts of marble and ſtone, the rocks which form the coaſt, appear at a great diſtance as ſo many pillars of marble perpendicularly divided. The coaſts of France from Breſt to Bourdeaux are almoſt every where ſurrounded with rocks juſt at the waters edge, very dangerous to mariners. The ſame are ſeen on the coaſts of England, Spain, and many others of the ocean and mediterranean, which are bordered with rocks and hard ſtone: excepting ſome parts which have been profitably made uſe of for bays, ports, and havens.

The depth of water along the coaſts, is generally ſo much the greater as the coaſts are more or leſs elevated; the inequality of the depth of the ſea along ſhore, alſo correſponds with the inequality of the ſurface of the ground, I ſhall here quote a paſſage from a celebrated navigator.

" I have conſtantly remarked that in thoſe parts where the coaſts is defended by ſharp rocks, the ſea is there very deep, ſo as ſeldom to afford a probability of anchoring, and on the contrary, where the ground inclined from the coaſt, however elevated it may be further inland, the bottom is good there, and conſequently admits of anchorage."

It is therefore certain, that there are inequalities in the bottom of the ſea, and very conſiderable mountains, according to the obſervations navigators have made with the lead. Divers likewiſe aſſure us, that there are other ſmaller inequalities formed by rocks, and that it is very cold in the vallies of the ſea; in general the depths increaſe in the great ſeas

ſeas, as we have already obſerved, in a very uniform manner, as they are more remote or nearer the ſhore. By Mr. Buache's map of a part of the ocean included between the coaſts of Africa and America, and by the diviſions he has given to the ſea between Cape Tagrin and Rio Grande, there appears to be inequalities in the ocean, as well as on land. That the Albrolhos where there are ſome rocks at the ſurface of the water, are only the tops of very large and lofty mountains, of which the iſland of Dauphiny is one of the higheſt peaks. That the iſlands of Cape Verd are alſo no more than the tops of mountains; that there a great number of ſhoals in the ſea, and that the ground round the Albrolhos deſcends even to unknown depths.

With reſpect to the quality of the differents ſorts which form the bottom of the ſea, as it is impoſſible to examine it cloſely, and that we muſt rely on Divers and the plumb, we can ſay nothing exact or preciſe concerning it; we only know that there are parts covered with mud to a conſiderable depth, on which anchors have no hold, in theſe parts probably the mud of rivers are depoſited. In other parts are ſands ſimilar to ours on land, and which like thoſe are found of different colours and ſize. In others are ſhells, heaped up together, madrepores, corals, and other animal productions, which begin to unite, and form ſtones; in others are fragments of ſtones, gravel, and even often entire ſtones and marble. For example, in the Maldivian iſlands the buildings are made of the hard ſtone which is weighed up from ſeveral fathoms depth under water. At Marſeilles very good marble is had from the bottom of the ſea, I have ſeen ſeveral ſamples of it, and ſo far from the ſea altering and ſpoiling the ſtone and marble; in our diſcourſe of minerals it is proved, that they are formed and preſerved in

in the ſea, whereas the ſun, earth, air, rain and water corrupts and deſtroys them.

We therefore cannot doubt but that the bottom of ſea is compoſed of the ſame matters as our habitable land, and that the ſame things are to be had from the bottom of the ſea as from the ſurface of the earth; ſo likewiſe ſpacious places are found at the bottom of the ſea, covered with ſhells, madrepores and other productions of ſea matters; as we meet with on earth an infinity of quarries and banks of chalk and other matters replete with theſe ſort of ſhells, madrepores, &c. ſo that in all reſpects the known parts of the globe reſemble thoſe covered by the water, whether for compoſition and mixture of matters, or for the inequalities of the ſuperficies.

It is to theſe inequalities of the bottom of the ſea, we muſt attribute the origin of currents; for it is eaſily conceived that if the bottom of the ocean was equal and level, there would be no other current in the ſea than the general motion from eaſt to weſt and a few other motions, which might be cauſed by the action of the winds and which would follow their direction: but a certain proof, that moſt currents are produced by the flux and reflux and directed by the inequalities of the bottom of the ſea, is, that they regularly follow the tides and change direction at each flux and reflux. See Pietro della Valle, on the ſubject of the currents of the gulph of Cambay, and the accounts of all navigators, who unanimouſly aſſert that in thoſe parts where the flux and reflux of the ſea is the moſt violent and impetuous; the currents there are alſo moſt rapid.

Therefore it cannot be doubted but that the flux and reflux produce currents whoſe directions always anſwers that of the oppoſite hills or mountains be-

between which they flow. Currents which are produced by winds, alfo follow the direction of thofe hills which are under the water, for they are not almoft conftantly directly oppofite to the wind which produces them, no more than thofe which are caufed by the flux and reflux, do not therefore follow the fame direction.

To give a clear idea of the production of currents, we fhall firft obferve, that they are to be met with in every fea, that fome are more rapid and others flow, that there are fome of great extent both in length and breadth, and others which are fhort and narrow; that the fame caufe, whether the wind, the flux and reflux, which produces thefe currents, gives to each of them a velocity and direction often different; that a north wind, for example, which fhould give the water one general motion towards the fouth throughout the whole extent of the fea where it acts, on the contrary produces a great number of currents feperated from each other and very different both in extent and direction. Some flow direct towards the fouth, others to the fouth eaft, and others to the fouth weft; fome are very rapid, others more flow, fome ftronger or weaker, fome broader and narrower than others, and that in fo great a Variety of combination, that we can find nothing fimilar to them except the caufe which produces them, and when a contrary wind fucceeds, as often happens at fea and regularly in the Indian ocean, all thefe currents take an oppofite direction to the firft, and follow in a contrary direction the fame roads and the fame courfe as that of thofe which went to the fouth, go to the north, thofe which flowed towards the fouth eaft, go towards the fouth weft, &c. having the fame extent in length and breadth, the fame velocity, and their courfe in the middle of the other waters of the fea, is precifely made after the fame

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mode as would be made on land between two opposite and adjacent ſhores : as is ſeen at the Maldivian iſlands and between all the iſlands of the Indian ſeas, where the currents go in the ſame direction as the winds for ſix months, and for the other ſix months in a contrary direction ; the ſame remark has been made on currents between banks of land, &c. and in general all currents whether cauſed by the motion of flux or reflux, or the action of the wind, have conſtantly the ſame extent, breadth and direction throughout their whole courſe, but very different from each other in length, breadth, rapidity and direction, which can proceed only from the inequalities of the hills, mountains and vallies at the bottom of the ſea ; as is obſerved between two iſlands, where the current follows according to the direction of the coaſts as well as between the banks of ſand, ſhoals, &c. We muſt therefore look on the hills and mountains of the bottom of the ſea, as ſhores which direct the current, and hence a current is a river the breadth of which is determined by that of the valley through which it flows, and the rapidity depends on the force which produces it, combined with the greater or leſſer breadth of the interval through which it muſt paſs, whoſe direction is traced by the poſition of the hills and inequalities between which it muſt take its coruſe.

This being underſtood, we ſhall give a palpable reaſon for this ſingular circumſtance, of this correſpondence of the angles of mountains and hills ; which are to be met with in every part of the world. By turning our eyes on rivulets, rivers, and all running waters, we ſhall perceive that the ſhores which confine them, always form alternative oppoſite angles ſo that when a river forms an elbow, one of the borders forms on one ſide a projection inland, and the other on the contrary, forms a point from land, and that through all the ſinuoſities of their courſe, this correſpond-

respondence is always found. It is in fact founded on the laws of the motion of the water, and the equality of the action of fluids, and it would be easy to demonstrate the cause of this effect, but it is here sufficient that it is general and universally known, and that all the world may be convinced of it by their own eyes, every time that the shore of a river forms a projection in land, which supposing to be the left hand, the other shore on the contrary, forms a projection from land on the right hand.

Hence the currents of the sea must be looked upon as great rivers, or running waters, subject to the same laws as the inland rivers and will like them form in the extent of their course, many sinuosities whose projections or angles will be different, and as the shores of these currents are hills and mountains above or below the surface of the water, they will have given these eminences the same form as is remarked on the shores of rivers. Therefore, we must not be astonished that our hills and mountains, which have been formerly covered by the sea, by the motion of the currents have taken this regular figure, and all the angles are alternately opposite; they have been the shores of the currents or rivers of the sea; and have therefore necessarily taken a figure and direction similar to those of the shores of the rivers of the earth, and consequently every time that the left shore shall have formed a projecting angle, the right will have formed a contrary one, as we may observe in all opposite hills.

This alone independent of the other proof, would be sufficient to evince, that the earth of our continent has been formerly submerged; and the use that I make of this observation of the correspondence of the angles of mountains, and the cause that I assign for it, appears to me to be the sources of light and demonstrations of the present subject. For it was not sufficient to have proved that the external

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ſtrata of the earth have been formed by the ſediments of the ſea; that the mountains are elevated by the ſucceſſive aſſemblage of ſuch ſediments; that they are compoſed of ſhells and other marine productions; but it is required alſo to give a reaſon for this regularity of the figure of hills, whoſe angles are correſponding, and to find the true cauſe of it: that no perſon till now, had even ſuppoſed it, and which nevertheleſs being united with the reſt forms a body of proofs, as complete as may be had in phyſics, and furniſhes a theory founded on facts, and independents of all hypotheſis, on a ſubject which has never been attempted in this manner; and on which it appeared to be permitted, and even neceſſary, to gain every aſſiſtance we could free from ſuppoſitions and hypotheſes, in order to be able to ſpeak of any think conſequential or ſyſtematical.

The principal currents of the ocean are thoſe obſerved in the Atlantic ſea, nor Guinea: they extend from Cape Verd to the bay of Fernandos: their motion is from weſt to eaſt, contrary to the general motion of the ſea from eaſt to weſt; theſe currents are very ſtrong, ſo that veſſels may ſail in two days from Moura to Rio de Benin, i. e. a courſe of more than 150 leagues, but they require more than ſix or ſeven weeks to return; they cannot even get out of this part, but by profiting of the tempeſtuous winds, which riſe all on a ſudden in theſe climates; but there are entire ſeaſons, during which they cannot ſtir, the ſea being continually calm, excepting what ariſes from the motion of the currents, which is always directed towards the coaſts in this part: theſe currents do not extend more than 20 leagues from ſhore. Near Sumatra there are rapid currents which flow from the ſouth towards the north, and which probably have formed the gulph between Java and Magellan. There are alſo very great currents betwixt the Cape of Good Hope and the

the iſland of Madagaſcar, and eſpecially on the coaſt of Africa, between the country of Natal and the Cape. In the Pacific ſea, on the coaſt of Peru, and the reſt of America, the ſea moves from ſouth to north, and a ſouth wind continually blows there, which ſeems to be the cauſe of theſe currents: the like motion is obſerved on the coaſts of Brazil; from Cape St. Auguſtine to the Antilles, at the mouth of the Manilla Strait, at the Phillipine iſlands, and in the port of Kubuxiu at Japan. (See Varen. Geography, page 140.

There are very violent currents in the ſea adjacent to the Maldivian iſlands, and between theſe iſlands theſe currents flow, as I have obſerved, conſtantly for ſix months from eaſt to weſt, and retrogade; during the other ſix months, they follow the direction of the monſoons; and it is probable they are produced by thoſe winds, which is known to blow in that ſea for ſix months from eaſt to weſt, and ſix months in a contrary direction.

To conclude, we ſpeak here only of currents whoſe extent and rapidity are very conſiderable: for in every ſea there are an infinity of currents known to mariners only by comparing the courſe they have made, with that which they ſhould have made, and they are often obliged to attribute the driving their veſſel to the action of theſe currents. The flux and reflux, the winds, and all other cauſes, which may give agitation to the waters, muſt produce currents, more or leſs perceptible in different parts. We have obſerved that the bottom of the ſea, like the ſurface of the earth is overſpread with mountains, ſtrewed with inequalities, and divided by banks of ſand: in all mountainous and divided places, currents will be violent; in all flat places where the bottom of the ſea is level, they will be almoſt imperceptible, the rapidity of the current will increaſe in proportion to the obſtacles the water meets with; or rather, to the con-

contraction of the ſpaces through which they incline to paſs. Between two chains of mountains in the ſea, a current will neceſſarily be formed, which will be ſo much the ſtronger as thoſe two mountains are cloſer : it will be the ſame between two banks of ſand, or two neighbouring iſlands. It is alſo remarked in the Indian ocean, which is divided with an infinity of iſlands and banks, that throughout there are very rapid currents, that renders the navigation of that ſea very dangerous. In general hese currents have directions ſimilar to thoſe of the winds, or the flux and reflux which produce them.

Not only all the inequalities of the bottom of the ſea, muſt form currents, but the coaſts themſelves muſt make partly a ſimilar effect, all coaſts cauſe the water to ebb at greater or leſſer diſtances, as this ebbing of the waters is a kind of current which circumſtances can render continual and violent. The oblique poſition of a coaſt, the vicinity of a gulph, or of ſome great river, a promontary; in one word, every particular obſtacle which oppoſes the general motion, will always produce a current. Now, as nothing is more irregular than the bottom and borders of the ſea, we muſt therefore, ceaſe from being ſurprized at the great number of currents every where met with.

All theſe currents have a determinate breadth, which does not vary, this breadth of the current depends on that of the interval which is between the two eminences which ſerves it for a bed. The currents flow into the ſea, as rivers flow on land, and they produce ſimilar effects : they form their bed and give to eminences, through which they flow, a regular figure, whoſe angles are correſpondent : In one word, it is theſe currents which hallowed our vallies, and gave to the ſurface of the earth, when it was ſubmerged, the form it now retains.

If any one doubts of this correſpondence of the angles

angles of mountains, I dare appeal to the ſight of every man, eſpecially when they have read what is above ſaid. I only require any one to examine as he travels, the poſition of oppoſite hills, and the projections which they make in the vallies, he will be convinced by his ſight that the valley was the bed, and the hills the ſhores of the currents, for the oppoſite ſides of a hill exactly correſpond, like two ſhores of a river. Whenever the hills to the right of the valley form a projection, the hills to the left of the valley form a neck: theſe hills have alſo nearly the ſame elevation, and it is very rare to ſee any great inequality of height in the two hills ſeperated by a valley. I can aſſert that the more I have looked on the circumference and heights of hills, the more I have been convinced of the correſpondence of the angles, and of the reſemblance they have with the beds and borders of rivers, and it is by reiterated obſervations in this ſurprizing regularity, and on that ſtriking reſemblance, that my firſt ideas on the theory of the earth aroſe; let us add to theſe obſervations, that of the parallel and horizontal ſtrata, that of the ſhells diſperſed throughout the earth, and incorporated in every matter, and we ſhall ſee if there can be any thing which can carry a greater probability with it, on a ſubject of this kind.

ARTICLE XIV.

Of regular Winds.

NOTHING appears more irregular and variable, than the force and direction of winds in our climates, but there are countries where this irregularity is not ſo great, and others where the wind conſtantly blows in one direction, and with almoſt the ſame ſtrength.

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Although the motion of the air depends on a great number of caufes, there are neverthelefs principal ones, of which we may eftimate the effects, but it is difficult to judge of the modifications which other fecondary caufes may bring thereto. The moft powerful of all thefe caufes, is the heat of the fun, which produces fucceffively a confiderable rarefaction in different parts of the atmofphere, which caufes the eaft wind that conftantly blows between the tropics, where rarefaction is the greateft.

The force of the fun's attraction and even that of the moon on the atmofphere, are caufes whofe effect is infenfible in comparifon of that which we have juft mentioned; it is true that this force produces in the air, a motion fimilar to that of the flux and reflux in the fea, but this motion is nothing in comparifon of the agitations of the air, which are produced by rarefaction: for it muft not be fuppofed that the air, becaufe it has a fpring, and is 800 times lighter than water, muft receive by the action of the moon a very confiderable flux: provided we reflect a little thereon, we fhall perceive that this motion is fcarcely more confiderable than that of the flux and reflux of the fea: for the diftance of the moon being fuppofed the fame, a fea of water, air, or any other like fluid matter, we chufe to imagine, will have nearly the fame motion, becaufe the force which produces this motion penetrates the matter, and is proportional to its quantity; thus a fea of water, air, or quickfilver, would elevate itfelf nearly to the fame height, by the action of the fun and moon; and hence we fee that the motion which the attraction of the planets may caufe in the atmofphere, is not confiderable enough to produce a ftrong agitation, and although it muft caufe a flight motion of the air from eaft to weft, this motion is totally infenfible in comparifon of that, which the heat of the fun muft produce by rarefying the air; and as the rarefaction will

will be always greater when the ſun is at the Zenith, it is clear that the current of air muſt follow the ſun, and form a conſtant and general wind from eaſt to weſt; this wind blows continually over the ſea in the torrid zone, and in moſt parts of the land between the tropics, it is the ſame wind as we feel at the ſun's riſing; and in general the eaſt winds are much more frequent and impetuous than the weſt; this general wind from eaſt to weſt extends even beyond the tropics, and blows ſo conſtantly in the pacific ſea, that veſſels which ſail from Acapulco to the Philippines, go that road, which is more than 2700 leagues without any riſque, and as we may ſay, without any need of the pilot's aid. It is the ſame with reſpect to the Atlantic ſea, between Africa and Brazil, this wind conſtantly blows there: it is felt alſo between the Philippines and Africa, but not in ſo conſtant a manner, by reaſon of the iſlands, and different obſtacles that are met with in that ſea, for during the months of January, February, March, and April it blows between the Mozambic coaſt and India, but during the other months it gives place to other winds: and although this eaſt wind is leſs felt on the coaſts than in the open ſea, and ſtill leſs in the middle of continents than on the coaſts of the ſea; nevertheleſs there are places where it almoſt continually blows, as on the oriental coaſts of Brazil, on the coaſts of Louango, in Africa, &c.

This eaſt wind which continually blows under the line, is the cauſe, that when we ſail from Europe to America, the courſe of the veſſel is directed from the north to the ſouth, in the direction of the coaſts of Spain and Africa, as far as 20 degrees on this ſide the line, where this eaſt wind is met with which carries us directly on the coaſts of America and again in the Pacific ſea, the voyage from Callao or Acapulco to the Phillippine iſlands, is made in two months by the favour of this eaſt wind: but the return from them to Acapulco is longer and more

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difficult; at 28 or 30 degrees of this coaſt from the line, we find the weſtern winds pretty conſtant, which is the reaſon that the veſſels which return from the Eaſt Indies to Europe, do not ſhape the ſame track as in going; thoſe from New Spain ſail along the coaſts and towards the north till they arrive at the Havannahs, and from thence they gain the norther coaſts to meet with the weſterly winds which carries them to the Acoras and afterwards to Spain; ſo likewiſe in the ſouthern ſea thoſe which return from the Phillipines, or from China to Peru or Mexico, gain the north as far as Japan, and navigate under that parallel to a certain diſtance from California, from whence, coaſting along New Spain, they arrive at Acapulco. Theſe eaſt winds do not always blow from one point, but in general are to the ſouth eaſt from April to November, and to the north eaſt from November to April.

The eaſt wind by its action contributes to increaſe the general motion of the ſea from eaſt to weſt; it alſo produces currents which are conſtant, and have their direction, ſome from eaſt to weſt, others from weſt to eaſt; and from the eaſt to the ſouthweſt or northweſt, following the direction of the eminences and chains of mountains which are at the bottom of the ſea, the vallies of which that divide them, ſerve as canals to theſe currents; ſo likewiſe the alternative winds which blow ſometimes from the eaſt, and ſometimes from the weſt, produce alſo currents which change direction at the ſame time as theſe winds do.

The winds which blow continually for ſome months, are generally followed by contrary winds, and mariners are obliged to wait for that which is favourable to them; when theſe winds change, a calm or dangerous tempeſt enſues for ſeveral days and ſometimes a month.

Theſe general winds cauſed by the rarefaction of the atmoſphere, combine differently by different cauſes

caufes in different climates; in part of the Atlantic fea, under the temperate zone, the north wind blows almoft conftantly during the months of October, November, December, and January, which is the reafon why thefe months are the moft favourable to embark from Europe to India, in order to pafs the line, by the favour of thefe winds, and it is known by experience, that fhips which quit Europe in the month of March do not arrive fooner at Brazil than thofe which fail in the month of October. The north wind almoft continually reigns during winter in Nova Zembla, and the other northern coafts: the fouth wind blows during the month of July to Cape Verd, when the rainy feafon, or winter of thefe climates fets in: at the Cape of Good Hope the north weft wind blows, during the month of September: at Patna, in India, this north weft wind blows during the months of November, December, and January, and produces heavy rains; but the eaft wind blows during the other nine months. In the Indian ocean, between Africa and India, as far as the Molucca iflands, the monfoons reign from eaft to weft from January to the beginning of June, and the weft winds begin in the months of Auguft and September, during the interval of June and July there are very great tempefts, generally from the north winds, but on the coafts, thefe winds vary much more than in the open fea.

In the kingdom of Guzarat, and on the coafts of the neighbouring fea, the north winds blow from the month of March, till the month of September and during the other months of the year, fouth winds almoft always reign. The Dutch, to return from Java, generally fet fail in the month of January or February by an eafterly wind which is felt as far as 18 degrees northern latitude, after which they meet with the fouth winds which carry them to St. Helena. See Varen. Geography, gener. cap. 20.

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There are regular winds produced by the melting of the ſnow: the ancient Greeks have taken notice of them. During ſummer the north weſt winds and during winter thoſe of the ſouth eaſt are felt in Greece, Thrace, Macedonia, the Egean ſea, and as far as Egypt and Africa; the ſame kind of winds are remarked at Congo, at Guzarat, and at the extremity of Africa, which are all produced by the melting of the ſnow. The flux and reflux of the ſea alſo produce regular winds which remain only a few hours, and in many parts, winds are obſerved which proceed from the land during night, and from the ſea during the day, as on the coaſts of New Spain, Congo, at the Havannah, &c.

The north winds are pretty regular in the climates of the polar circles; but the more we approach the equator, the weaker are theſe north winds, which is common to the two poles.

In the Atlantic and Ethiopian ocean, there is an eaſt wind which is general between the tropics, laſting all the year without any conſiderable variation, excepting ſome few ſmall places, where it changes according to the circumſtances and poſition of the coaſts; 1. Near the coaſts of Africa, as ſoon as we have paſſed the canary iſlands, you are ſure of meeting with a freſh wind, from the north eaſt to about 28 degrees north latitude, this wind ſeldom paſſes the north eaſt or the north weſt, and it accompanies you as far as 10 degrees north latitude, to about 100 leagues from the coaſt of Guinea, where at the 4th degree north latitude we meet with calms and tornadoes: 2d. Thoſe which go to the Carribbean iſlands, in approaching America, find that this wind from the north eaſt veers more and more to the eaſt, in proportion as they approach it nearer: 3dly. The limits of theſe variable winds, in this ocean, are greater on the American coaſts, than on thoſe of Africa. There is a part in this ocean, where the

ſouth and the ſouth weſt winds are continual; viz. all along the coaſt of Guinea in a ſpace of 500 leagues, from Sierre Leona as far as the iſland of St. Thomas; the narroweſt part of that ſea is from Guinea as far as Braſil, about 500 leagues. Nevertheleſs ſhips which ſail from Guinea, do not direct their courſe ſtrait to Braſil, but they deſcend from the ſouthern coaſt, eſpecially when they ſet ſail in the month of July and Auguſt, by reaſon of the the ſouth eaſt winds which reigns at that time. See Abridg. Phil. Than. vol. 11. p. 129.

In the Mediterranean, the winds blow from the land towards the ſea at the ſuns ſetting and on the contrary from the ſea towards the land at its riſing, ſo that in the morning it is an eaſterly wind and in the evening a weſterly wind; the ſouth wind which is rainy and which generally blows at Paris, Burgundy, and Champagne at the beginning of November, and which cedes to mild and temperate breezes, produces the fair weather vulgarly called the ſummer of St. Martin's.

Doctor Liſter, in other reſpects a good naturaliſt, pretends that the general eaſt wind obſerved between the tropics all the year, is produced only by the reſpiration of the plant called the *ſea lentil*, which is extremely plentiful in thoſe climates, and that the difference of the winds on the land proceeds only from the different diſpoſition of the trees and foreſts, and he very ſeriouſly gives this ridiculous imagination for a cauſe of the wind, by ſaying, that at noon the wind is ſtronger becauſe the plants are hotter and reſpire the air oftener, and that it blows from eaſt to weſt, becauſe all the plants turn and reſpire with the ſun.

Other authors, who have ſeen clearer into the cauſe of this conſtant wind, have mentioned the motion of the earth on its axis; but this opinion is only ſpecious, and it is eaſy to make

persons, even but little initiated in mechanics comprehend, that all fluids which surround the earth, cannot have particular motion from the rotation of the globe; that the atmosphere can have no other motion than that of this rotation, and that all turning together at one time, this motion of rotation is as insensible in the atmosphere as it is on the surface of the earth.

The principal cause of this constant motion is, as we have observed, the heat of the sun, on this subject we refer to Halley's Treatise in Phil. Trans. and in general all causes which in the air will produce a considerable rarefaction or condensation, will produce winds whose directions will be always direct or opposite to the places where the greatest rarefaction or condensation shall be.

The pressure of the clouds, the exhalations of the earth, the inflamation of meteors, &c. are causes also which all produce considerable agitations in the atmosphere. Each of these causes combining in different manners, produces different effects: it appears to me therefore, that we vainly attempt to assign a theory of the wind; and that we must limit ourselves, by studying to form the history of it, and it is with this view that I have collected circumstances which might serve thereto.

If we could have a course of observations on the direction, power, and variation of the wind, in different climates; if this course of observations was exact and extensive enough, for us to see at one glance, the result of these vicissitudes of the air in every country, I do not doubt, that we should arrive to that degree of knowledge, from which we are very remote; to a method by which we might foresee and predict the different states of the heavens and the difference of the seasons; but a short time has passed since meteorological observations have been

been made, and much lefs fince they have been made with care, and poffibly much more will pafs before we know how to employ the refults of them, which neverthelefs, are the only means that we have to arrive at fome pofitive knowledge on this fubject.

On the fea, the winds are more regular than on the land, becaufe the fea is an open fpace in which nothing oppofes the direction of the wind: on land, on the contrary, mountains, forefts, towns, &c. form obftacles which change the direction of the wind, and which often produce contrary winds. Thefe winds reflected by the mountains, are felt in all the different provinces, with an impetuofity which is often as great as that of the direct wind, which produces them: they are likewife very irregular, becaufe their direction depends on the fize, height, and fituation of the mountains which reflect them. The fea winds blow with greater power than the land winds, they are alfo not fo variable, and laft longer. Land winds however violent they may be, have moments of remiffion, and fometimes of quiet: in thofe of the fea, the current of wind is conftant and continual, without any interruption, the difference of thefe effects depends on the caufe we have juft indicated.

In general, on the fea, the eaft wind and thofe which come from the poles, are ftronger than the weft and thofe which proceed from the equators. On the land, on the contrary, the weft and fouth winds, are more or lefs violent than the eaft and north winds, according to the fituation of the climates. In fpring and autumn, the winds are more violent than in fummer or winter, as well on fea as land, we can give many reafons thereon. 1. Spring and autumn are the feafons which form the higheft tides, and confequently the wind, that thefe tides produce are more violent in thefe two fea-

ſeaſons: 2. the motion which the action of the ſun and moon produce in the air, that is to ſay, the flux and and reflux of the atmoſphere, is alſo greater in the ſeaſon of the equinoxes; 3. the melting of the ſnow in ſpring, and the reſolving of the vapours that the ſun raiſes during ſummer, which refall in plentiful rains during autumn, produce, or at leaſt increaſe the wind; 4. change from heat to cold cannot be made without increaſing and diminiſhing conſiderably, the volume of air, which alone muſt produce very high winds.

Contrary currents are often obſerved in the air; clouds which move in one direction, and others which are higher or lower than the firſt which move in a contrary direction; but this contrariety of motion does not remain very long, and is commonly produced only by the reſiſtance of ſome clouds to the action of the wind and by the re-action of the direct wind which reigns ſolely as ſoon as the obſtacle is diſſipated.

The winds are more violent in mountainous places than in plains, and the higher we aſcend, the more the power of the wind increaſes untill we reach the common height of the clouds, that is to ſay, to about one quarter or one-third of a league perpendicular height; beyond that height the ſky is generally ſerene, at leaſt during the ſummer, and the wind low. It is even aſſerted to be quite inſenſible at the ſummit of the higheſt mountains, notwithſtanding the greateſt part and even the higheſt of theſe ſummits, being covered with ſnow and ice, it is natural to ſuppoſe that this region of air is agitated by the wind when the ſnow falls; therefore it can be only during ſummer that the winds are to be felt. Might it not be ſaid that in ſummer the light vapours which riſe to the ſummit of theſe mountains, fall in the form of dew, whereas in winter they condenſe, freeze, and fall in ſnow or ice, which in

in winter may produce winds below these mountains, although there is no summer.

A current of air increases in velocity, like a current of water, where the space of its passage is straitened, which is rarely perceptible in a wide and open plain, the same wind which was moderate in an open plain, becomes violent in passing through a narrow passage between two mountains, or simply between two lofty buildings and the point of the most violent action of the wind is above these structures or mountain strait. The air being compressed by the resistance of these obstacles has a greater mass, density and the same velocity subsisting; the effort or gust of wind, the *momentum* becomes much stronger, this is the cause that near a church, or a castle, the winds seem to be much stronger, than they are at a certain distance from these edifices. I have often remarked, that the wind reflected by an isolated building does not prevent it from being more violent than a direct wind, which produced this reflected wind, and since I have endeavoured to discover the reason of this, I have been able to find no other than the above, the impelled air compresses against the building and is reflected, not only with its former velocity, but also with a greater body, which, in fact, renders its action much more violent.

Not to consider that the density of the air, which is greater at the surface of the earth than in every other point of the atmosphere, we might be led to imagine that the greatest action of the wind should be likewise at the surface of the earth, and I indeed think that this is really the case when the sky is serene; but when it is covered with clouds, the most violent action of the wind is at the height of rain or snow. We must therefore say, that the strength of the wind must be estimated, not only by the velocity, but also by the density of the air, from whatsoever cause this density might proceed, and that it

it muſt often happen that one wind which ſhall have no more velocity than another, will neverthe-leſs root up trees, and overturn buildings, only from the air impelled by this wind being denſer; this evinces the imperfection of the machines in-vented to meaſure the velocity of the wind.

Particular winds, whether direct or reflected, are more violent than general winds. The interrupted action of land winds depends on this compreſ-ſion of the air, which renders each blaſt much more violent than it would be if the wind blowed uniform-ly: however a ſtrong continued wind may be, it never occaſions the diſaſters, which the rage of the wind produces, which blows, if I may expreſs my-ſelf ſo, by fits; we ſhall give examples thereof in the following article.

We might conſider wind, and their directions, under general points of view, from which poſſibly we might derive uſeful inductions: for example, it appears to me probable to divide the winds by zones, that the eaſt wind, which extends to about 25 or 30 degrees on each ſide the equator, muſt be regarded as exerciſing its action all around the globe in the torrid zone: the north wind almoſt always as conſtantly in the frigid zone, as the eaſt wind in the torrid zone; and it has been diſcovered that at Terra del Fuega, and in the moſt remote parts of the northern pole which have been diſcovered, the wind comes alſo from the pole. Therefore it may be ſaid that the eaſt wind occupying the torrid zone; the north wind occupies the friged zone: and with reſpect to the temperate zone, the winds which reign there are, if I may uſe the expreſſion, only currents of air, whoſe motion is compoſed of thoſe two winds whoſe direction tends to the weſt; and with reſpect to the weſterly winds, whoſe direction tends to the eaſt, and which often reign in the temperate zone, whether in the paci-

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fic fea, or in the atlantic ocean, may be regarded as winds reflected by the lands of Afia and America, the firft origin of which is due to the eaft and north winds.

Although we have faid that generally fpeaking, the eaft winds reign around the globe to about 25 or 30 degrees on each fide the equator, it is neverthelefs certain that in fome parts they extend to a much lefs diftance, and their direction is not every where from the eaft to the weft; for on this fide the equator it is a little eaft north eaft, and beyond the equator it is eaft fouth eaft, and the further we remove from the equator, whether to the north, or to the fouth, the more the direction is oblique, the equator is the line, under which the direction of the wind, from eaft to weft is the moft exact: for example, in the Indian ocean the general wind from eaft to weft fcarcely extends beyond 15 degrees. Sailing from Goa to the Cape of Good Hope this wind is not met with till we have paft the equator: but when we arrive at the 12th degree fouth latitude, this wind is met with to the 28th degree fouth latitude. In the fea which divides Africa from America, there is an interval from the 4th degree to the 10th or 11th degree north latitude, where this general wind is not fenfible; but beyond this 10th or 11th degree, this wind reigns, and reaches the 30th degree.

There is alfo much exception to be made to the fubject of the monfoon winds, whofe motion is alternative. Some remains a longer or fhorter time, others extend to greater or lefs diftances, others are more or lefs regular, or more or lefs violent. We fhall here relate after Verenius the principal phænomena of thefe winds. "In the Indian ocean between Africa and India as far as the Molucca's, the eaft winds begin to reign at the month of January, and laft till the beginning of June; in the month of

of Auguſt or September begins the contrary motion, and the weſt winds reign during three or four months; in the intervals of theſe monſoons, that is to ſay, at the end of June, in the month of July, and beginning of Auguſt, there is no wind on that ſea, but they have violent ſtorms, which come from the north.

Theſe winds are ſubject to the greateſt variations drawing near land, for ſhips cannot depart from the Malabar coaſt, no more than the other weſtern coaſts of the peninſula of India, to ſail to Africa, Arabia, Perſia, &c. than from the month of January to the month of April and May; for from the end of May, and during the months of June, July, and Auguſt there are ſuch violent tempeſts formed by the north or north eaſt winds, that ſhips are not able to ſtand out to ſea; on the contrary, on the other ſide of this peninſula, that is to ſay, on the ſea which bathes the Coromandel coaſt, theſe tempeſts are not known.

To ſail from Java, Ceylon, and many other parts, to the Molucca iſlands, the month of September is the moſt proper time, becauſe the weſt wind then begins to blow in theſe parts; nevertheleſs, when we remove from the equator to 15 degrees north latitude, we loſe this weſt wind and meet with the general wind, which is ſouth eaſt to ſail from Cochin to Molucca, in the month of March; becauſe the weſt winds begin to blow at that time, therefore theſe weſterly winds are perceptible at different times in the Indian ſea; we ſail then as we have obſerved, at one time from Java to the Molucca's, at another time to go from Cochin to Molucca, at another time to go from Molucca to China, and alſo at another time to ſail from China to Japan.

At Banda the weſt winds finiſh to the end of March, then reigns variable winds and calms during the month of April, at the month of May the eaſt winds

winds begin again with a great violence ; at Ceylon, the wefterly winds begin towards the month of March, and remains till the beginning of October, when the eaft or rather north eaft wind returns : at Madagafcar from the middle of April to the end of May the north and north weft winds are to be met with, but in the month of February and March the eaft and fouth winds reign : from Madagafcar to the Cape of Good Hope, the north and collateral winds blow during the months of March and April : in the Gulph of Bengal, the fouth wind blows ftrongly after the 20th of April ; before which time the fouth weft or north weft winds reign in that fea : the weft winds are alfo very violent in the fea of China, during the months of June and July, which is likewife the moft fuitable feafon to go from China to Japan ; but to return from Japan to China, the months of February and March are preferred, becaufe the eaft or north eaft winds reign then in that fea."

"There are winds which may be regarded as particular to certain coafts ; for example, the fouth wind is almoft continual on the coafts of Chili and Peru, it begins at the 46th degree, or thereabouts, fouth latitude, ahd extends beyond Panama, which renders the voyage from Lima to Panama, much eafier performed than the return. The weftern winds blow almoft continually, or at leaft very frequently, on the Magellanic coafts, and o'er the environs of the ftrait of Maire : the north and north weft winds almoft continually reign on the Malabar coaft : the north weft wind is alfo very frequent on the coaft of Guinea, and at a certain diftance from that coaft, in the open fea we meet with the north eaft wind very frequently : the wefterly winds reign on the coafts of Japan, in the months of November and December."

The alternative or periodical winds, which we have juft been fpeaking of, are fea winds ; but there

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are alſo land winds, which are periodical, and return either at a certain ſeaſon, or in certain days, or even at certain hours; for example, on the Malabar coaſt, from the month of September to April a land wind blows from the eaſtern ſide, this wind generally commences at midnight and finiſhes at noon, and is not felt beyond 12 or 15 leagues from the coaſt, and from noon till midnight a weak ſea wind reigns, which comes from the weſt: on the coaſt of New Spain in America, and on that of Congo in Africa, land winds reign during the night, and ſea winds during the day: at Jamaica the winds blow from all quarters at once during the night, and veſſels cannot then come in, nor depart from it with ſafety in the day time.

In winter the port of Cochin is not to be entered and no veſſel can quit it, becauſe the winds blow there with ſuch impetuoſity, that ſhips cannot remain at ſea, and beſides the weſterly winds which blow there with ſuch fury, brings to the mouth of the river Cochin ſo great a quantity of ſand as prevents the poſſibility of ſhips and even barks from entering it during ſix months of the year; but the eaſt winds which blow during the other ſix months, repels theſe ſands into the ſea, and renders the entrance of the river free. At the ſtrait of Babel-mandel there are ſouth eaſt winds which reign there throughout the ſeaſon, and which are always ſucceeded by north weſt winds. At St. Domingo there are two different winds, which regularly riſe almoſt every day, the one a ſea wind proceeding from the eaſtern coaſt and commences at 10 o'clock in the morning, the other a land wind, which comes from the weſt, riſes at ſix or ſeven o'clock in the evening, and remains all night. There are many other circumſtances of this nature to be extracted from travellers, the knowledge of which, might perhaps lead us to give a hiſtory of

of winds which might be a very ufeful work for navigation and phyfics.

ARTICLE XV.

Of irregular Winds, Hurricanes, and fome other Phenomena caufed by the Agitation of the Sea and Air.

THE winds are more irregular on the land, than on the fea, and more irregular in the higher lands than in plains. The mountains not only alter the direction of winds, but even they produce winds, which are either conftant or variable according to different caufes; the melting of the fnow, which is upon the mountains, generally produces, conftant winds, which fometimes remain very long; the vapours which are ftopt by mountains which accumulate there, produce variable winds, very frequent in all climates, and there are fo many variations in thefe motions of the air, as there are inequalities on the furface of the earth. We can therefore give only examples on this point, and relate circumftances which are attefted, and as we are deficient in a courfe of obfervations on the variation of winds, and even on that of the feafons in different countries, we do not pretend to explain all the caufes of thefe differences, and we confine ourfelves to thofe which appear the moft natural and propable,

In the ftraits, on all the projecting coafts, at the extremity and in the environs of all promontories, peninfulas and capes and in all narrow gulphs, ftorms are frequent: but beyond that there are feas much more tempeftuous than others. The Indian ocean, the Japan fea, the Magellanic fea, that of the African coaft beyond the Canaries, and on the other fide towards the country of Natolia, the Red fea, &c. are

are very liable to ſtorms. The Atlantic ocean is more ſtormy than the ocean, which is called from its tranquility, the *Pacific Sea*; nevertheleſs this Pacific ſea is not abſolutely tranquil, except between the tropics, and about the temperate zones, and the more we approach the poles, the more we are ſubject to variable winds, whoſe ſudden change often cauſes tempeſts.

All terreſtrial continents are ſubject to variable winds, which often produce ſingular effects: in the kingdom of Cachemira, which is ſurrounded by the mountains of Caucaſus, at the mountain *Pire Pinjale*, ſudden changes are experienced; we paſs, as I may ſay, in leſs than an hour from ſummer to winter: two winds directly oppoſite reigns there, the one north and the other ſouth, which according to Bernier, we ſucceſſively experience in leſs than 200 feet diſtance; the poſition of this mountain muſt be irregular, and merit obſervation. In the peninſula of India which is croſſed from north to ſouth by the mountains of Gate, there is winter on one ſide of them, and ſummer on the other ſide at the ſame time, ſo that on the coaſt of Coromandel the air is ſerene, tranquil, and very hot, whereas at that of Malabar, although under the ſame latitude, the rains, ſtorms, and tempeſts, render the air as cold as it poſſibly can be in that climate; and on the contrary when it is ſummer at Malabar, it is winter at Coromandel. The like difference is met with on the two ſides of Rozalgate Cape in Arabia, in a part of the ſea which is to the north of the cape there reigns a great tranquility, whereas in the part which is to the ſouth violent tempeſts are experienced. It is likewiſe the ſame in the iſland of Ceylon, winter and high winds are experienced in the northern parts of the iſland, whereas in the ſouthern parts, there is very fine ſummer weather; and on the contrary, when the northern part enjoys the mildneſs of ſummer

mer, the ſouthern part in its turn is plunged in a dark, ſtormy, and rainy air. This not only happens in many parts of the Indian continent, but alſo in many iſlands; for example, at Ceram, which is a long iſland in a vicinage at Amboyna, they have winter in the northern part of the iſland, and ſummer at the ſame time in the ſouthern part, and the interval that divides the two ſeaſons, is not above three or four leagues.

In Egypt during ſummer, very often hot ſouth winds reign, which diſturbs the reſpiration, and raiſes ſo great a quantity of ſand, that the ſky ſeems covered with thick clouds; this ſand is ſo fine and driven with ſuch force, that it penetrates every where, even into the cloſeſt coffers, when theſe winds laſt many days they cauſe epidemical diſeaſes, which are often followed by a great mortality. It very ſeldom rains in Egypt, nevertheleſs every year there are ſome days rain during the months of December, January, and February; thick miſts are alſo formed which are more frequent there than rain, eſpecially in the environs of Cairo, theſe miſts begin in the month of November and continue during winter, they riſe before the ſun riſes; during the whole year there falls ſo plentiful a dew, when the ſky is ſerene, that it might be taken for a ſlight rain.

In Perſia winter begins in November and remains till March, the cold is intenſe enough there to form ice, and much ſnow falls in the mountains, and often a little in the plains; from the month of March to that of May, winds riſe which blow with great ſtrength, and bring heat with them: from the month of May to September the ſky is ſerene and the heat of the ſeaſon moderate during night, through the freſh breezes which riſe every evening and remain till the enſuing morning. In autumn there are winds, which like thoſe of the ſpring, blow ſtrongly: nevertheleſs, although theſe winds are very violent, it is very rare that

that they produce hurricanes and tempeſt: but in ſummer there often ariſes along the Perſian gulph, a very dangerous wind, called by the natives *Samyel*, which is ſtill hotter and more terrible than that of Egypt, which we have juſt ſpoken of: this wind is mortal and ſuffocating, its action is almoſt ſimilar to that of a whirlwind of enflamed vapour, and the effects cannot be avoided when any perſon is unfortunately enveloped therein. In ſummer on the Red ſea, and in Arabia there alſo ariſes a wind of the ſame kind, which ſuffocates men and cattle, and which carries off ſo great a quantity of ſand, that many perſons aſſert that this ſea will in time be choaked by the ſucceſſive gatherings of ſand which fall therein. There are often ſome clouds of ſand in Arabia, which darken the air and form dangerous whirlwinds. At Vera Cruz when the north wind blows, the houſes of the town are almoſt buried under the ſand, which a ſlight wind brings thereto. In ſummer alſo hot winds riſe at Negapatan in the peninſula of India, as well as at Petapouli and Maſulipatan; theſe burning winds which deſtroy people, are fortunately but of ſhort duration, but very violent, and the greater ſwiftneſs they come with, the more burning they are, whereas all other winds refreſh ſo much the greater as their velocity is found to be: this difference proceeds only from the degree of heat in the air: as long as the heat of the air is not ſo great as that of the body of animals, the motion of the air is refreſhing, but if the heat of the air is greater than that of the body, then the motion of the air heats and burns; at Goa the winter or rather the rainy and tempeſtuous ſeaſon, is in the months of May, June, and July, without which the heat would be inſupportable in that country.

The Cape of Good Hope is famous for its tempeſts, and the ſingular cloud which produces them: this cloud appears at firſt only like a ſmall round ſpot

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in the ſky, called by the ſailor's *the Ox's Eye*, I imagine it appears ſo minute from its exceeding great height. Of all the travellers who have ſpoken of this cloud, Kolbe appears to be the only one who examined it with ſtrict attention, his words are as follow: vol. 1. page 224, &c. "The cloud ſeen on the mountains of the *Table*, or of the *Devil*, or of the *Wind*, is compoſed, if I am not deceived, of an infinity of ſmall particles, impelled firſt againſt the mountains of the Cape, towards the eaſt, by the eaſterly wind which reigns during almoſt the whole year in the torrid zone; theſe particles thus impelled are ſtopt in their courſe by theſe high mountains, and collect on their eaſtern ſide: then they become viſible and form theſe aſſemblage of clouds, which being inceſſantly driven by the eaſt wind, riſe to the ſummit of theſe mountains; they do not long remain there tranquil, obliged to advance, they ingulph themſelves between the hills before them, where they are bound and confined like a canal, the wind preſſes them underneath, and the oppoſite ſides of the two mountains retain them in a direct line: wheh in advancing they arrive at the foot of a mountain, where the country is a little more open, they extend and unfold theſmelves, and become again inviſible, but they are preſently driven on the mountains, by other clouds which are behind them, and thus arrive with much impetuoſity on the the higheſt mountains of the cape, which are thoſe of the *Wind* or *Table*, where a contrary wind blows; then it makes an hideous conflict, being impelled behind and repelled before, which produces horrible whirlwinds, either on the high mountains I ſpeak of, or in the valley of the Table where theſe clouds would precipitate. When the north weſt wind has quitted the field of battle, the ſouth eaſt increaſes and continues to blow with more or leſs violence, it reinforces itſelf while the cloud of the

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Ox's Eye is thick, becauſe the particles which arrive there collect behind it: it diminiſhes as ſoon as its thickneſs is leſſened becauſe fewer particles preſs behind: it is entirely lowered when the cloud is no longer apparent, becauſe there is no new or not ſufficient particles any longer comes from the eaſt; the cloud in ſhort never diſappears, or rather always appears of the ſame ſize, becauſe the new matters replace behind thoſe which are diſſipated in front.

All theſe phenomenical circumſtances leads to an hypotheſis, which well explains every part of them: behind the mountain of the *Table* we remark a train of light white miſts, which commencing on the eaſtern deſcent of this mountain, incline to the ſea, and occupy the Stony mountains throughout all their extent, I was very often employed in contemplating this train, which, according to my opinion was cauſed by the rapid paſſage of the particles abovementioned, from the Stony mountains to that of the Table."

Theſe particles which I ſuppoſe muſt be extremely embarraſſed in their road, by the frequent ſhocks and counter ſhocks cauſed not only by the mountains, but alſo by the ſouth and eaſt winds which reign at places circumjacent to the Cape: I have already ſpoken of the two mountains ſituate on the points of *Bay Falgo*, or Falſe Bay, when the particles which I conceive are impelled on theſe mountains by the eaſterly winds, they are repelled from them by the ſouth, which carry them on the neighbouring mountains; they are ſtopt there and appear in clouds, like thoſe formed on the two mountains of Bay Falgo; theſe clouds are often very thick on *Hottentot Holland*, on the mountains of *Stenltenborch*, of *Drakenſtein*, and *Stone*, but particularly on the mountain of the *Table*, and on that of the *Devil*.

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In ſhort, what confirms my opinion is, that conſtantly two or three days before the ſouth eaſt wind blows on the *Lion's Head*, ſmall black clouds are perceived to cover it; theſe clouds according to my opinion, are compoſed of the particles which I have ſpoken of; if the north weſt wind ſtill reigns when they arrive there, they are ſtopt in their courſe, but are never driven to a great diſtance till the ſoutheaſt winds commence.

The firſt mariners who approached the Cape of Good Hope, were ignorant of the effects of theſe fatal clouds, which forms in the air ſo ſlowly, tranquilly and without any motion, and which all at once flaſhes the tempeſt, and cauſes a ſtorm which precipitates veſſels to the bottom of the ſea, eſpecially when the ſails are unfurled. In Natolia, a ſmall cloud alſo forms ſimilar to the *ox's eye*, at the Cape of Good Hope, and from this cloud iſſues a terrible wind, which produces the like effects. In the ſea between Africa and America, eſpecially under the equator and in the neighbouring parts of it, theſe kind of tempeſts very often ariſe; near the coaſt of Guinea ſometimes three or four of theſe ſtorms are formed in a day, they are cauſed and announced, like thoſe of the Cape, by ſmall black clouds: the reſt of the ſky is generally very ſerene, and the ſea calm. The firſt blaſt which iſſues from theſe clouds is furious, and would ſink ſhips in open ſea, if they did not take the precaution to furl the ſails: it is principally in the months of April, May and June that theſe tempeſts are experienced on theGuinea ſea, becauſe no regular wind blows there during the ſeaſon; the ſeaſon of theſe ſtorms on the adjacent ſea to the coaſts of Loango, are thoſe of the month of January, February, March and April. On the other ſide of Africa, at the Cape of Giradafu, theſe kinds of tempeſts riſe in the month of May and the

clouds which produce them are generally in the north like thoſe of the Cape of Good Hope.

All theſe tempeſts are therefore produced by the winds which iſſue from a cloud and which have a direction, either to the north or ſouth, north eaſt or ſouth weſt, &c. but there are other kinds called *hurricanes*, which are ſtill more violent than theſe, and in which the winds ſeem to proceed from all the coaſts, they have a whirling motion which nothing can reſiſt. A calm generally precedes theſe horrible tempeſts, and the ſea then appears as a piece of ſea : but in an inſtant the fury of the winds raiſes waves as high as the clouds. There are parts of the ſea, where we cannot land, becauſe alternatively there are always calms and hurricanes of this kind : the Spaniards have called theſe places *calms and tornados*, the moſt conſiderable are near Guinea at two or three degrees north latitude, they are 300 or 350 leagues in length by as many in breadth, which forms a ſpace more than 100,000 leagues ſquare : a calm or ſtorms are almoſt continual on the coaſt of Guinea, and there are veſſels which have been retained there three months without being able to quit it.

When to contrary winds come all at once in the ſame place, as to a center, they produce theſe whirlwinds by the contrariety of their motions; but when theſe winds meet with other winds in oppoſition which counterbalance their action; then they turn round a great ſpace in which a perpetual calm reigns, and this is what forms the calms we ſpeak of and from which it is impoſſible to get out. Theſe parts of the ſea are marked on Senex's globes, as well as the directions of the different winds which generally reign in all the ſeas. In fact, I ſhould be inclined to believe that the contrariety alone of the winds could not produce that effect, if the direction of the coaſts and the particular form of the bottom of the ſea in theſe

thefe places did not contribute thereto, I imagine therefore that the currents caufed by the winds, but directed by the form of the coafts and the inequalities of the bottom of the fea, all incline in certain places, and that their oppofite and contrary direction form tornados in a plain furrounded on all fides by a chain of mountains.

Gulphs appear to be no other than the eddies of the water formed by the action of two or more oppofite currents: the Euripus fo famous for the death of Ariftotle, alternately abforbs and rejects the water feven times in twenty-four hours; this gulph is near the Grecian coaft. The Charybidis which is near the ftrait of Sicily, rejects and abforbs the water thrice in twenty-four hours: on the whole we are not quite certain of the number of alternatives of motion in thefe gulphs. Doctor Placentia in his treatife called *Egeo Redivivo*, fays, that the Euripus has irregular motions for eighteen or nineteen hours in a month, and regular motions for eleven; that in general it fwells only one foot and feldom two: he fays likewife, that authors do not agree on the flux and reflux of the Euripus; that fome affert, that it is made twice, fome feven, others fourteen times in twenty-four hours, but that Loirius having examined it for a whole day, he obferved it every fix hours in an evident manner and with fo violent a motion, that each time it was able to turn the wheel of a mill round.

The greateft known gulph is that of the Norway fea, which is affirmed to be upwards of twenty leagues circuit. It abforbs for fix hours all what is nigh it, water, fhips, &c. and afterwards returns them in the fame quantity of time as it drew them in.

It is not neceffary to fuppofe there are holes and abyffes in the bottom of the fea which fwallow up the waters continually, to affign a reafon for the gulphs: it is well known that when water has two

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contrary directions, the composition of these motions produce a circular whirling and seem to form a void place in the center of this motion, as may be observed in many places near the piles which support the arches of Bridges, especially in rapid rivers: it is the same with respect to gulphs of the sea, they are produced by the motion of two or three contrary currents, and as the flux and reflux are the principal cause of currents, so that during the flux they are directed from one side, and during the reflux they go in a contrary direction. It is not at all astonishing, that the gulphs which result from these currents, attract and swallow up all what surrounds them for many hours, and afterwards in the same quantity of time reject all they have absorbed.

Gulphs therefore are only the eddies of the water produced by opposite currents, and hurricanes are only whirlwinds produced by contrary winds: these hurricanes are common in the sea of China and Japan, in that of the Antilles and in many other parts of the sea, particularly near projecting lands and high coasts; but they are still more frequent upon land and their effects are sometimes prodigious. "I "have seen, says Bellarmin, I should not have "thought if I had not been an eye witness, an en-"ormous ditch dug up by the wind, and all the earth "thereof carried to a village, so that the part from "whence the earth had been taken away, appear-"ed a frightful hole and the village was entirely "buried by this transported earth."

In the history of the Acad. Sciences and in the Philosophical Transactions, the detail of the effects of many hurricanes which appear inconceivable and scarcely credible, if the facts were not attested by a great number of ocular, veridical and intelligent testimonies.

It is the same with respect to the waterspouts, which mariners never see without fear and admira-

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tion: these water spouts are very frequent near certain coasts of the Mediterranean, especially when the sky is very cloudy and the wind blows at the same time from many sides. They are more common near the coasts of Laodicea, Grecgo and Carmel, than in other parts of the Mediterranean. Most of these waterspouts, are so many cylinders of water which fall from the clouds, although it sometimes appears, particularly, when we are at some distance, that the water of the sea rises in the air. (See Shaw's Travels, vol. 2. p. 56.)

But we must distinguish two kinds of waterspouts, the first of which, the waterspout we spoke of, is no other than a thick compressed cloud, reduced to a small space by opposite and contrary winds, which blowing at the same time from many corners, give the cloud the form of a cyndrical whirlpool, and causes the water to fall all at once under this cyndrical form; the quantity of water is so great and the fall so sudden and precipitate, that if unfortunately one of these spouts falls on a vessel, it fills and sinks it in an instant. It is asserted and possibly with foundation, that firing several guns charged with bullets at it, breaks it, and that this commotion of the air causes it to cease suddenly; this amounts to the effect of bells which are rung to disperse clouds charged with thunder and hail.

The other kind of waterspout called *thyphon*, which many authors have confounded with the hurricane, particulary in speaking of the storms of the Chinese sea, which is in fact subject to both, altho' they have quite different causes. The thyphon does not descend from the clouds like the first kind of hurricanes, but rise up from the sea with great violence and although these thyphons resemble whirlwinds which rise on the land, yet they have quite another origin. We perceive when the wind is contrary

trary and oppoſite, hurricanes raiſe up whirlwinds of ſands; and earth, and often houſes, trees and animals are raiſed in the air and tranſported to different parts. Sea thyphons on the contrary remain in the ſame place, and have only ſubterraneous fires for their origin; for the ſea is then in a great agitation and the air ſo ſtrongly filled with ſulphurous exhalations, that the ſky appears covered with a copper coloured cruſt, although there are no clouds, and the ſun and ſky may be ſeen through them. It is to theſe ſubterraneous fires the warmth of the ſea of China in winter may be attributed to, as theſe thyphons are very frequent there. See Acta Eud. Lipſ. Supplementum. vol. 1. p. 405.

We ſhall give ſome examples of the manner in w hich they are produced, Thevenot in his voyage to the Levant, ſays, " we ſaw water ſpouts in the Perſian gulph between the iſlands Queſomo, Lareca, and Ormus. I think very few people conſidered water ſpouts with as much attention as I have done, in the rencounter which I ſpeak of, and perhaps the remarks have never been made which chance gave me an opportunity of doing. I ſhall mention them with all the ſimplicity which I profeſs through the whole recital of my voyage, in order to render things plain, and eaſy to be comprehended."

" The firſt which appeared to me was on the northern coaſt, between us and the iſland Queſomo, at a gun ſhot from the ſhip, the head of the ſhip was then to the north eaſt: we directly perceived water which boiled on the ſurface of the ſea about a foot high, it was whitiſh, and appeared above that height like a thick black ſmoke, ſo that it properly reſembled ſome burning ſtraw, which only ſmoked; it made a noiſe like that of a torrent which runs with much rapidity in a deep valley: but this noiſe was mixed with a clearer, ſimilar to the ſtrong hiſſing of ſerpents or vipers; a little while afterwards we per-

perceived ſomething like a dark canal, which bore a ſtrong reſemblance to a ſmoke which aſcends towards the clouds turning round with great velocity, this appeared about the thickneſs of my finger, and the ſame noiſe ſtill continued; the duration of this ſpout was no longer than about half a quarter of an hour: this over, we perceived another on the ſouth ſide of us, which began in the ſame manner as the preceding: and almoſt as ſoon, a like one made its appearance on the weſt ſide; and directly after a third by the ſide of this ſecond, the fartheſt of the three might be about a muſket ſhot diſtance from us: they all three appeared like three burning heaps of ſtraw, a foot and a half or two feet high. We afterwards ſaw as many canals which deſcended from the clouds, on thoſe places where the water was raiſed up, and each of them was as broad at the end faſtened to the cloud, as the broad end of a trumpet, and was of the ſame ſhape, (to ſpeak intelligibly) as the breaſt or teat of an animal, drawn perpendicularly down by an heavy weight; theſe canals appeared of a darkiſh white, and I think it was the water, which was in theſe tranſparent canals, which made them appear white; for apparently they were already formed before the water entered therein, according to what could be judged from what followed; and when they were empty, they were no longer to be ſeen, like to a clear glaſs tube placed at ſome diſtance before our eyes is not perceptible if it is not filled with ſome coloured liquor. Theſe canals were not ſtrait, but crooked in ſome places, they even were not perpendicular; but on the contrary, from the clouds where they were joined to the parts, which drew in the water, they were very much bent; and what is more particular, is that the cloud where the ſecond of theſe three was faſtened to, having been driven by the wind, this canal followed it without breaking or quitting the place where it drew in the

water

water, and passing behind the first canal, they were sometimes crossed like a Saltire or St. Andrew's Cross. At the beginning they were all three about the thickness of my finger, but afterwards the first of the three increased considerably: with respect to the two others, I have nothing else to say; for the last which was formed scarcely remained longer than that which we saw on the north side. The second on the south side remained about a quarter of an hour, but the first on that side remained a little longer and this was that which terrified us the most; and what I have something farther to speak of. At first its canal was as thick as my finger, afterwards as thick as my arm, then as my leg, and at last as the trunk of a large tree, which a man might compass with his arms. We distinctly perceived water through this transparent body which ascended in a serpentine manner. Sometimes it diminished a little in size, sometimes at top and sometimes at bottom, then it resembled exactly a tube with some fluid matter pressed with the fingers, either upwards to make this liquor descend, or at bottom to cause it to ascend, and I am persuaded that it was the violence of the wind which caused these changes, causing the water to ascend very quickly when it pressed the canal at the bottom, and causing it to descend when it pressed the canal at top. After this it diminished so much in thickness that it was thinner than my arm like a gut, that is lengthened by drawing it perpendicularly, afterwards it returned as thick as my thigh and then again became very thin; at last, I saw the water risen on the surface of the sea begin to lower, and the end of the canal which touched it divided and grew narrower, and then the light which appeared to us by means of a cloud disturbed our sight of it: I did not desist still from observing whether it returned or not, because I had remarked that for three or four times the canal of the second of this same south

side

ſide had appeared to us to be broken in the middle, and directly after we ſaw it whole, and it was only the light which hid the half from us; but though I looked with the utmoſt attention, I ſaw this ſpout no more.

These waterſpouts are very dangerous: for if they come on a veſſel, they entangle in the ſails, ſo much, that ſometimes they raiſe it up, and afterwards letting them fall, they ſink to the bottom. This particularly happens when the ſhip or bark is ſmall: at leaſt, if they do not lift the veſſel up, they tear all the ſails, or let all the water they contain fall on them, which often ſinks them to the bottom. I do not in the leaſt doubt, but it was by ſimilar accidents that many ſhips of which we have heard no news, have been loſt, ſince there are but too many examples of thoſe that we have known from certainty to have periſhed in this manner."

I ſuſpect that there are many optical illuſions in the phænomena which this traveller relates: but I have been very glad to recount matters as he ſaw them, in order that we might verify them, or at leaſt compare them with thoſe which other travellers have related. The following deſcription will no doubt prove agreeable to our readers. "At eleven o'clock in the morning the air being filled with clouds, we perceived about our veſſel, at a quarter of a mile diſtant, ſix ſea ſpouts, which formed with a hoarſe noiſe, ſimilar to that of water flowing in ſubterraneous canals: this noiſe by degrees increaſed and reſembled the whiſtling, which the cordage of a ſhip makes when an impetuous wind blows among it. We at firſt obſerved the water to boil up about a foot and an half above the ſurface of the ſea; there appeared a mixt or rather a thick ſmoke above this boiling, of a pale colour, and this ſmoke formed a kind of canal which aſcended to the cloud.

"The canals or channals of these spouts inclined "according as the wind moved, the clouds to which "they were attached, and in spite of the winds impulsion, they not only did not detach themselves, "but even lengthened themselves to follow them, "growing thinner and thicker in proportion as the "cloud rose or lowered.

"These phenomena terrified us greatly, and our "sailors instead of being bolder, fomented their fears "by the tales they told each other. If these spouts, "said they, was to fall on our vessel, they will lift "it up, and afterwards letting it fall again, they "will sink it: others (who were the officers) an-"swered in a decisive tone that they would not "raise the vessel up, but if they met it in their "course they would break the communication they "had with the sea and being filled with water, all "they concluded that it would fall perpendicularly "on the deck of the vessel and split it.

"To prevent this misfortune, the cannon was "loaded, the sailors pretending that the report "of a cannon by agitating the air, dissipated these "phenomena; but we had no need of having re-"course to this remedy: for when they had run "about ten minutes about the ship, some at a quar-"ter of a league, others at a less distance, we per-"ceived the canals to grow narrower and narrower, "till they got loose from the surface of the sea and "then dissipated."

It appears from the description given by these two travellers, that waterspouts, are produced at least in part, by the action of a fire, or a smoke which rises from the bottom of the sea with great force; and that they are quite different from other kind of water spouts produced by the action of contrary winds and by the forced compression and sudden dissoluti-on of one or more clouds, as Shaw describes them. See Shaw, vol. 2. p. 56.

"The

" The water ſpouts, ſays he, which I had an opportunity of ſeeing, appeared to me as ſo many cylinders of water which fell from the clouds, altho' by the reflexion of the columns which deſcend or by the drops which detach themſelves from the water they contain and fall again into the ſea, it ſometimes ſeems, eſpecially when we are at ſome diſtance that the water riſes up from the ſea. To render a reaſon for this phenomena we may ſuppoſe that the clouds being being collected in one part by oppoſite winds, they force them by preſſing them with violence, to condenſe and deſcend in whirlpools."

There ſtill remains a number of circumſtances to be acquired before we can give a complete explanation of theſe phenomena ; it appears to me only that if there are under the waters of the ſea, ſoils mixed with ſulphur, bitumen and minerals, as we can ſcarcely doubt of, it may be conceived that theſe matters inflaming, produce a great quantity of air newly generated and prodigiouſly rarefied, eſcapes and aſcends with rapidity, that muſt raiſe and may produce theſe water ſpouts which riſe from the ſea towards the ſky : ſo likewiſe, if by inflammation the ſulphurous matters which a cloud contains, a current of air is formed, which deſcends perpendicularly from the clouds towards the ſea, all the aqueous parts contained in the cloud may follow the current of air and form a water ſpout which will fall from the ſky upon the ſea : but it muſt be allowed that the explanation of this kind of water ſpout, no more than that which we have explained by the eddy of the winds and the compreſſion of the clouds, is not ſatisfactory to every one ; for a perſon would be right who aſked us, why we do not ſee theſe kinds of waterſpouts which fall perpendicularly from the clouds as often on the land as on the ſea.

The hiſtory of the Academy, anno 1727, makes mention of a land waterſpout which appeared at Capeſtan,

ſtan near Beziers: it was a very black pillar which deſcended from a cloud to the earth, and diminiſhed in breadth as it approached the earth where it terminated in a point: it obeyed the wind which blew from weſt to ſouth weſt: it was accompanied with a kind of very thick ſmoke, and a ſimilar noiſe to that of a very troubled ſea, tearing away a quantity of olive branches, barking trees, and carrying away a large nut tree to the diſtance of forty or fifty feet, marking its way by a broad well beaten track, on which three coaches might paſs abreaſt: there appeared another pillar of the ſame ſize, but which ſoon joined to the firſt, and after the whole had diſappeared, a great quantity of hail fell on the earth.

This kind of waterſpout appears to be ſtill different from the two others; it is not mentioned that it contains water, and it ſeems as much by what I have related, as by the explanation given thereon by M. Andoque, when he preſented the obſervation: of this phenomena to the academy, that this waterſpout was only a whirlwind of thick wind rendered viſible by the duſt and condenſed vapours which it contained. See the Hiſtory of the Academy anno 1727, p. 4, &c.

In the ſame hiſtory, anno 1741, a waterſpout is ſpoken of, ſeen on the lake of Geneva, which was a pillar whoſe upper part inclined to a very black cloud and whoſe lower part which was narrower, terminated a little above the water, this phenomena remained only a few minutes, and at the moment it was diſſipated, a thick vapour was perceived which deſcended from the part where it had appeared, the waters of the lake alſo boiled and ſeemed to make an effort to riſe up. The air was very calm during the time this waterſpout appeared, and when it was diſſipated neither wind nor rain enſued. "With all what we are already acquainted with, ſays the hiſtorian

torian of the academy, concerning marine water ſpouts, might it not be another proof that they are not formed by the conflict of the winds, and that they are almoſt always produced by ſome eruption of ſubterraneous vapours, or even volcano's, from which we know the bottom of the ſea is not exempt? The whirlwinds and hurricanes, which we commonly thought to be the cauſe of theſe ſort of phenomenas, might poſſibly be] then only the effect, or an accidental event hereof." See Hiſtory of the Acad. an. 1741, page 20.

ARTICLE XVI.

Of Volcanos and Earthquakes.

THE burning mountains called volcano's, includes in their bowels ſulphur, bitumen, and matters which ſerve as aliment to a ſubterraneous fire, the effect of which is more violent than that of gunpowder or thunder, has from the firſt knowledge aſtoniſhed, terrified mankind, and deſolated the country. A volcano is a cannon of an immenſe volume, whoſe orifice is often more than half a league: this wide fire mouth has vomited forth torrents of ſmoke, flame, rivers of bitumen, ſulphur, and melted metal, clouds of cinders and ſtones, and ſometimes it ejects enormous rocks to many leagues diſtance, which human powers united could not move: the combuſtion is ſo terrible, and the quantity of burnt, melted, calcined, and vitrefied matters which the mountain throws out, is ſo plentiful, that they enter cities, foreſts, covers the fields an hundred and two hundred feet in thickneſs, and forms ſometimes hills and mountains, which are only heaps of theſe piled up matters. The action of this fire is ſo great, the force of exploſion ſo violent, that it produces by its re-

action

action very powerful succours to shake and move the earth, agitate the sea, overthrow mountains, and destroy the most solid towns and edifices, even to very considerable distances.

These effects, although natural, have been looked upon as prodigies, and although we see in miniature the effects of fire, nearly similar to those of volcanos, in the great, of what nature soever they be, has so greatly the right of astonishing us, that I am not surprized that some authors have taken these mountains for the vents of a central fire, and the people for the uusfortunate in Hell. Astonishment produces fear, and fear is the mother of superstition. The natives of the island of Iceland, imagine that the roarings of the volcano are the cries of the damned, and its eruptions the effects of the rage and despair of these unhappy wretches.

All this notwithstanding is only noise, fire and smoke: veins of sulphur, bitumen, and other inflamable matters, are found in a mountain; minerals and pyrites are also met with there, which may ferment, and which in fact do ferment, every time they are exposed to the air or humidity: a very great quantity is found together, they catch fire and cause an explosion, proportionate to the quantity of inflamed matters, and whose effects are also greater or less in the like proportion. This is a volcano to a real philosopher, and it is easy for him to imitate the action of these subterranean fires, by mixing together a certain quantity of brimstone and iron filings, and burying them in the earth to a certain depth, and by this means make a little volcano, whose effect will be similar in proportion with those of the great, for it inflames by fermentation alone: it throws off the earth and stones with which it is covered, and smokes, flames, and explodes like a volcano.

In

In Europe are three famous volcanos, mount Etna in Sicily, mount Hecla in Iceland, and mount Vesuvius in Italy near Naples. Mount Etna has burnt from time immemorial, its eruptions are very violent, and the matters it throws out so plentiful, that they may be dug to the depth of 68 feet, where we meet with marble pavement, and the vestiges of an ancient town which has been covered and buried under this thickness of matter thrown out from the mount, in the same manner as the city of Heracleus has been covered by the matter thrown out from Vesuvius. New mouths of fire were formed in 1680, 1669, and at other times: we see the flame and smoke of this volcano from Malta, which is about 60 leagues distance from it, it smokes continually, and there are times when this burning mountain vomits flames and matters of every kind with impetuosity. In 1537, there was an eruption of this volcano, which caused an earthquake in Sicily for 12 days, and which overthrew a very great number of houses and structures, it ceased only by the opening of a new fire mouth, which burnt every thing for five miles in the environs of the mountain; the cinders thrown out by the volcano were so abundant, and ejected with so much force, that they were driven as far as Italy; and vessels which were departed to some distance from Sicily, were incommoded by them. Farelli describes the conflagration of this mountain circumstantially, and says the foot of it is 100 leagues in circumference.

This volcano has now two principal mouths, the one narrower than the other; these two vents always smoke, but fire is never seen to issue from it, but during the time of eruptions: it is pretended that stones are found which it has thrown out to the distance of 60,000 feet.

In 1683, a terrible earthquake happened in Sicily, caused by a violent eruption of this volcano, it entirely

tirely destroyed the town of Catanea, and killed more than 60,000 persons in that town only, without reckoning those which were destroyed in the neighboring towns and villages.

Hecla throws out its fires through the ice and snow of a frozen land, its eruptions are nevertheless as violent as those of Etna, and other volcanos of southern countries. It throws out many cinders, pumice stones, and sometimes, it is said, boiling water: it is not inhabitable at the distance of six leagues from this volcano, and the whole island of Iceland is very abundant in sulphur. The history of the violent eruptions of Hecla may be seen in Dithman and Bleffken.

Mount Vesuvius, according to historians, did not begin burning till the 7th Consulate of Titus Vespasian and Flavius Domitian, the top being opened, this volcano threw out at first stones and rocks and afterwards fire and flames in such great abundance, that they burnt two neighbouring towns, and emitted such thick smoke that it obscured the light of the sun. Pliny desirous of examining this conflagration nearer was suffocated by the smoke. See the Epistle of Pliny, jun. to Tacitus.

Dion Cassius relates, that this eruption of mount Vesuvius was so violent, that it cast out cinders and sulphurous smoke in such great quantities and with such force that they were driven as far as Rome, and even beyond the Mediterranean sea into Africa. One of the two towns covered with matters thrown out by this first conflagration of Vesuvius, is that of Heracleus, which in these latter times have been discovered at more than 60 feet depth under these matters, the surface of which was become by length of time a cultivable land: the relation of the discovery of Heracleus is in the hands of the public, it would be only to desire any one versed in Natural History and physics, to take the trouble of examin-

mining the different matters which compoſe this thick ſoil of 60 feet, paying attention at the ſame time, to the diſpoſition and ſituation of theſe matters, to the alterations they have produced or ſuffered, to the direction they have taken and to the hardneſs they have acquired.

There is an appearance that Naples is ſituate on a hollow ground, and filled with burning minerals, ſince Veſuvius and Solfatera ſeem to have interior communications: for when Veſuvius burns Solfatera emits flames, and when it ceaſes, Solfatera alſo ceaſes. The city of Naples is ſituate nearly between the two.

One of the laſt and moſt violent eruptions of mount Veſuvius was that in the year 1737. The mountain vomited by divers mouths large torrents of burning metallic matters, which diſperſed themſelves over the country and into the ſea. Monſ. Monteſquieu, who communicated this relation to the Academy of Sciences, obſerved with horror one of theſe rivers of fire, and ſaw its courſe for ſix or ſeven miles till it reached the ſea; its breadth was ſixty or ſeventy feet, its depth, twenty-five or thirty palms and in certain bottoms or vallies, 220, the matter which flowed was like the ſcum which iſſues from the furnace of a forge, &c. (See the Hiſt. Acad. an. 1737, p. 788.

In Aſia, particularly in the iſlands of the Indian ocean, there is a great number of volcanos, one of the moſt famous is mount Albours near mount Taurus, eight leagues from Heaut, its ſummit continually ſmokes, and it frequently throws out flames and that the ſurrounding country is covered with cinders. In the iſland of Temet, there is a volcano which throws out matter like the pumice ſtone. Some travellers aſſert that this volcano is more inflamed and furious in the time of the equinoxes, than in any other ſeaſon of the year, becauſe certain winds

then reign there which continue to consume the matter which feeds, and has fed this fire, for such a number of years. See Argensola's Travels, vol 1. page 21. The island of Temet is only seven leagues round, and is only the summit of a mountain: we ascend it on every side from the shore till we reach the middle of the island, where the volcano rises to a considerable height, and to which it is very difficult to attain; many rivulets of fresh water run there which descend on the ridge of this mountain, and when the air is calm, and the season mild, this burning gulf is in a less agitation, than when there are high winds and storms. (See the Travels of Schouten.) This confirms what I have said in my former discourse, and seems evidently to prove that the fire which consumes the volcano, does not proceed from the depth of the mountain, but from the top, or at least from a very trifling depth, and that the chimney of the conflagration is not far distant from the summit of the volcano: for if it was not so, the high winds could not contribute to their combustion. The are some other volcanos in the Moluccas: in one of the Maurice islands, 70 leagues from the Moluccas, there is a volcano whose effects are as violent as those of Mount Ternet. Socca island, one of the Moluccas, was formerly inhabited; in the middle of this island was a volcano, which was a lofty monutain: in 1693, this volcano vomited bitumen and inflamed matters in such a great quantity as to form a burning lake, and the whole abyss was abyss'd and disappeared. (See Phil. Transf. ab. vol. II. page 391.) At Japan there is also many volcanos, and in the adjacent islands of Japan, mariners have remarked many mountains whose summits have emitted flames during the night, and flames during the day time. At the Phillippine islands, there are also burning mountains. One of the most famous volcano's of the

the islands in the Indian ocean, and at the same time one of the newest, is that near the town of Parucan, in the island of Java, it opened in 1586, no person ever heard of its burning before; and at the first eruption it threw out an enormous quantity of sulphur, bitumen and stones. The same year Mount Gounapi, in the island of Banda which burnt only 17 years, opened and vomited with a frightful noise, rocks, and emitting matters of every kind. There are also some other volcanos in India, as at Sumatra, and in the north of Asia.

In Africa, there is a mountain, or rather a cavern called, *Benguazevel*, near Fez, which always emits smoke, and sometimes flames. One of the islands of Cape Verd, called the island of *Fuogue*, is only a large mountain which continually burns; this volcano, like the rest, throws out many cinders and stones, and the Portuguese who have attempted several times to erect habitations in this island, have been constrained to abandon this project, through the dread of the effects of the volcano. The Canaries, the Peak of Teneriff, and some of the highest mountains of the earth, and throws out fire, cinders, and large stones; from the top rivulets of melted sulphur flow which are distinguishable at a great distance.

In America there are a great number of volcanos, particularly in the mountains of Peru and Mexico; that of Arequipa, is one of the most famous, it often causes earthquakes more common in Peru than any other country in the world. The volcano of Carrappa and that of Malahallo are according to the report of travellers, the most considerable, next to that of Arequipa, but there are many others of which we have no exact knowledge. M. Bouguer, in the relation he has given the world of his voyage to Peru, in the volume of the Memoirs of the Aca-

Academy of the year 1744, makes mention of two volcanos, called Cotopaxi and Pickincha ; at the firſt at ſome diſtance the other very nigh the town of Quito ; he was even witneſs of a conflagration of Cotopaxi in 1742, and of the orifice which was made in that mountain, this eruption did no other damage than melting of the ſnow of the mountain, and producing ſuch plentiful torrents of water, that in leſs than three hours they inundated a tract of country 18 leagues in extent, and overthew all they met with in their way.

At Mexico are many vulcanos, the moſt conſiderable of which are Pocochampe and the Popolatepec, but this laſt volcano, Cortes paſſed in his voyage to Mexico, and ſome of the Spaniards aſcended to the top, where they ſaw the mouth of this volcano, which was about half a league in circumference. Theſe ſulphurous mountains are alſo be met with at Guadaloupe, Tercera, and other iſlands of the Acoras, and if we place among the number of theſe volcanos all theſe mountains which ſmokes or emits flames, we may reckon more than ſixty ; but we have only ſpoken of thoſe formidable volcanos, near which no perſon dares to inhabit, and which throw out ſtones and mineral matters to a great diſtance.

Theſe volcanos which are in ſuch great numbers in the Cordilliers, cauſe, as I have ſaid, almoſt continual earthquakes, which prevents the natives from building with ſtone above one ſtory high, and not to run the riſque of being cruſhed, they conſtruct the upper ſtories of their houſes with reeds and light wood. In theſe mountains are alſo many precipices and large vents, the ſides of which are black and burnt, as in the precipice of mount Azaret in America, which is called the ABYSS : theſe abyſſes are the mouths of old extinguiſhed volcanos.

There

There was lately an earthquake at Lima, the effects of which are terrible: the town of Lima and Port Callao have been almoſt entirely abyſſes; but the evil has been ſtill greater at Callao. The ſea has covered all the edifices, and conſequently drowned the inhabitants, and only one tower is now remaining. Of twenty-five ſhips which were in this port, there were four which were carried a league in land, and the reſt were ſwallowed up by the ſea. At Lima, which is a large town, there remains only twenty-ſeven houſes ſtanding, and a great number of perſons were buried in the ruins, particularly Monks and religious perſons, as their edifices were higher and conſtructed of more ſolid materials than the other houſes. This misfortune happened in the month of October 1746, at night when the ſhock remained 15 minutes.

There was formerly near the port of Piſco, at Peru, a famous town ſituate on the ſea ſhore, which was almoſt entirely deſtroyed and deſolated by the earthquake which happened the 19th of October 1682: for the ſea having quitted its common bounds, ſwallowed up this unfortunate place, which has been attempted to be re-eſtabliſhed about a quarter of a league from the ſea.

If we conſult hiſtorians and travellers, we ſhall find relations of many earthquakes and eruptions of volcanos, the effects of which have been as terrible as thoſe we have juſt mentioned. Poſidonius, whom Strabo quotes in his firſt book, relates, that there was a town in Phenicia, ſituate near Sidon, which was ſwallowed up by an earthquake, and with it the neighbouring territory, and even two thirds of the town of Sidon; and that this effect was not ſo ſuddenly executed, but that many of the inhabitants had time to avoid it by flight. This ſhock extended throughout all Syria, and as far as the Cyclad iſlands, and into Eubea, where the foun-

fountains of Arethuſa ſtopt all at once and did not re-appear for many days after, by many new ſprings remote from the old ones. This earthquake alſo did not ceaſe from ſhaking the iſland, ſometimes in one part and ſometimes in another, until the earth opened in the country of Lepanto, and a great quantity of earth and other inflamed matters were thrown out. Pliny in his firſt book, chap. 84, relates that in the reign of Tiberius an earthquake happened which overthrew twelve towns in Aſia: and in his ſecond book, he mentions in the following terms a prodigy cauſed by an earthquake; he ſays, that by a great earthquake there was 100 towns overthrown in Lybia. In the time of Trajan, the town of Antiochus and a great part of the adjacent country were ſwallowed up by an earthquake; and in the time of Juſtinian in 528, this town was a ſecond time deſtroyed by the ſame cauſe, with upwards of 40,000 of its inhabitants and ſixty years after, in the time of Saint Gregory, it felt the effects of a third earthquake, with the loſs of 60,000 of its inhabitants. In the time of Saladin in 1182, moſt of the towns of Syria and Jeruſalem were deſtroyed by the ſame cauſe. In Calabria and Poh, there has been more earthquakes than in any other part of Europe. In the time of pope Pius XI. all the churches and palaces of Naples were overthrown and above 30,000 of its inhabitants killed, and all thoſe which remained alive were obliged to live in tents, till they had rebuilt their houſes. In 1629, there were earthquakes in Pola, which deſtroyed 7000 perſons, and in 1638, the town of Saint Euphemia was ſwallowed up, and there remain only a ſtinking lake in its place. Raguſa and Smyrna were alſo almoſt deſtroyed. There was an earthquake in 1692, which extended into England, Holland, Flanders, Germany, and France, it was chiefly felt on the

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ſea coaſts and near large rivers, its ſhock was felt at leaſt 2600 leagues ſquare; it laſted only two minutes, and the motion was more conſiderable in the mountains than in vallies. (See Ray's Diſcourſes, page 272.) On the 10th of July, 1688, there was an earthquake at Smynra, which begun by a motion from weſt to eaſt, the caſtle was at firſt overthrown, its four walls being divided and ſunk ſix feet in the ſea: this caſtle which was an iſthmus, is at preſent a real iſland, about 100 paces diſtant from the ſea, in the part where the neck of land is wanting. The walls which was from eaſt to weſt are fallen down, thoſe from north to ſouth are yet ſtanding, the town which is 10 miles from the caſtle, was deſtroyed almoſt at the ſame time: in many places openings in the earth are ſtill to be ſeen, and divers ſubterraneous noiſes heard; five or ſix ſhocks were felt in the night, the firſt laſted only half a minute, the ſhips which were in the road were ſhaken, the ground of the town was lowered about two feet and a quarter, of the town only remained, principally the houſes which ſtood on rocks: 15 or 20,000 perſons are computed to have been buried under the ruins by this earthquake. (See the Hiſt. of the Acad. des Sciences, anno 1688.) In 1695, in an earthquake felt at Boulogne in Italy, it was remarked as a particular thing that the water was troubled a day before. (See the Hiſt. of the Acad. anno 1696.

" At Tercera there happened ſo great an earthquake on the 4th of May 1614, that in the town of Angra it overthrew eleven churches and nine chapels, excluſive of particular houſes, and in the town of Praya it was ſo terrible, that not an houſe was left ſtanding: and on the 16th of June 1628, there was ſo horrible an earthquake in the iſland of St. Michel, that the ſea near it opened, and threw up in one place where it was more than an 150 fathom deep

deep an iſland more than a league and an half long, and upwards 60 fathom high. (See the Travels of Mandelſo.) " Another happened in 1691, which begun the 16th of July, and laſted in the iſland of St. Michel till the 12th of the following month: Tercera and Fayal were agitated the next morning with ſo much violence, that they appeared to turn, but theſe frightful ſhocks returned only four times, whereas at St. Michel they did not ceaſe a moment for 15 hours. The iſlanders having quitted their houſes which they ſaw fall before their eyes, paſſed all that time expoſed to the injuries of the weather. A whole town named Villa Franca, was overthrown to the very foundation, and moſt of the inhabitants buried under its ruins. In many parts the plains roſe into hills, and in others, ſome mountains flattened or changed ſituation. A ſpring of water iſſued from the earth, which flowed for four hours, and which appeared dry all on a ſudden. The air and ſea ſtill more agitated reſounded with a noiſe which might have been taken for the roaring of a quantity of wild beaſts. Many perſons died with the fright, and the ſhips in the ports ſuffered dangerous ſhocks, and thoſe which were at anchor, or under ſail at 20 leagues diſtant from the iſlands, ſuffered greater damage. Earthquakes are frequent in the Acoras: there was one in Manilla, in the month of September 1627, which levelled one of the two mountains called Carvellos in the province of Cagayan; in 1645, one third of the town was deſtroyed by a like accident, and 300 perſons periſhed. The ſucceeding year it underwent another; the ancient indians ſay that they were more terrible formerly, and that this is the reaſon they build their their houſes only of wood, which made the Spaniards follow, from the firſt ſtory.

" The quantity of volcanos to be met with in

this iſland, confirms what has hitherto been advanced; becauſe, at certain times they vomit forth flames, ſhake the country and perform all the effects Pliny attributes to thoſe of Italy; that is to ſay, they change the beds of rivers, fill with cinders the adjacent parts and throw out ſtones to a great diſtance, with a report ſimilar to that of cannon. See le Voyage de Gemelli Careri, page 129.

"In the year 1646, the mountain of the iſland of Machian ſplit with terrible reports, by an earthquake, an accident which is very common in that country, ſo many fires iſſued through this opening, as conſumed many negro-yards with the inhabitants and all that was therein. In the year 1685, this prodigious crack was to be ſeen and ſtill is apparent; it is called the path of *Machian*, becauſe it deſcends from the bottom like a road hollowed out, but which at a diſtance appears like a path." See the Hiſt. of the conqueſt of the Moluccas, vol. iii. p. 318.

The hiſtory of the Academy makes mention in the following terms, of the earthquakes in Italy in 1702 and 1703, "The earthquakes began in Italy in the month of October 1702, and continued till the month of July 1703; the country which ſuffered the moſt by them, and where they likewiſe began, is the town of Norci, with its dependencies under the eccleſiaſtical government and the province of Abruzzo, theſe countries are contiguous and ſituate at the foot of the Apennine mountains on the ſouth ſide."

"Earthquakes have often been accompanied with terrible noiſes in the air, which have alſo been heard without ſuch dreadful effects, when the ſky was ſerene. The earthquake which happened on the 2d of February 1703, was the moſt violent of all; it was accompanied, at leaſt at Rome, with a great ſerenity of ſky and calmneſs in the air. It

lasted at Rome half a minute, and at Aquila the capital of Abruzzo three hours. It destroyed the whole town of Aquila, buried 5000 persons under the ruins, and made great havock in the environs.

"It opened two places in a field, from whence issued a great quantity of stones, which entirely covered it and rendered it barren, after the stones it threw out two *jets d'eau* which greatly surpassed the height of the trees of that country, lasted half an hour and inundated as far as the adjacent fields, this water was whitish like to soapy water, and had not the least taste."

"A mountain near Sigillo, a city twenty-two miles distant from Aquila, had on its summit a very large plain surrounded with rocks which served it for walls. Since the earthquake of the 2d of February, in the place of this plain a gulph of unequal breadth was formed, whose greatest diameter was twenty-five fathom and the least twenty, the depth of it has never yet been discovered, although they have let down a line 300 fathom feet in length. At the time when this opening was made, flames were seen to issue out, and afterwards a great smoke which lasted three days with some interruptions."

"At Genis the 1st and 2d of July, 1703, there were two slight earthquakes, the last was felt only by the people who worked on the pier: at the same time the sea in the port sunk six feet, so that the galley touched the bottom; this falling of the water remained a quarter of an hour."

The sulphurous water which is in the road from Rome to Tivoli, is diminished two feet and a half as well in the bason as in the ditch. In many places of the plain called *Testine*, there were springs and rivulets of water which formed impracticable morasses, all which are dried up. The water of the lake called *Hell* is also lowered three feet. In the place of the ancient springs which are stopt, new ones

ones have iſſued a league from the firſt, ſo that there is an appearance that they are the ſame waters which have changed direction." Anno 1704, page 10.

" The ſame earthquake which in 1538 formed mount Cineris, near Pouzzol, filled at the ſame time lake Lucrin with ſtones, earth and cinders, ſo that actually this lake is a marſhy ground." SeeRay's diſcourſes, p. 12.

" There are earthquakes which are felt for ſome diſtance at ſea, M. Shaw relates, that in 1721, being on board the Gazelle an Algerine veſſel, mounting 50 guns, three violent ſhocks were felt one after the other, as if every time a weight of twenty or thirty tuns had been thrown on the ſhip, this happened in a part of the Mediterranean which was 200 fathom deep. He relates alſo, that others had felt earthquakes much more conſiderable in other parts, and one among the reſt at forty leagues weſt from Liſbon." See Shaw's travels, vol. I. p. 303.

Schouten ſpeaking of an earthquake in the Molucca iſlands, ſays, that the mountains were ſhaken and the veſſels which were at anchor at thirty or forty fathom were ſhocked, as if they had ſtruck againſt thoſe rocks or banks. " Experience, continues he, teaches us every day that the ſame things happens in the open ſea, where no bottom is to be met with, and that when the earth ſhakes, ſhips are toſſed to and fro even where the ſea was tranquil." See vol. I. p. 103.

Gentil in his voyage round the world, ſpeaks of earthquakes of which he was witneſs, in the following terms, " I have, ſays he, made ſome remarks on theſe earthquakes : the firſt is, that half an hour before the earth is agitated, every animal is ſtruck with fear, horſes ſnort, break their faſtenings and fly from the ſtable, dogs bark, birds are frightened and almoſt ſtupified fly into houſes, and

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rats and mice quit their holes, &c. the second is, that vessels at anchor are so violently agitated, that every part of them seem as if going to pieces, the cannon quit their port holes, the masts by this agitation break in several places, which I should scarcely have given credit to, if many unanimous testimonies had not convinced me. I therefore conceive that the bottom of the sea is a continuation of the land, that if this land is agitated, it communicates its agitation to the waters it carries to it; but what I do conceive is, that this irregular motion of the vessel, of which every timber and part taken separately participates of this agitation, as if all the vessels formed a part of the earth, and did not float in a fluid matter, its motion must be similar to that it undergoes in a storm: besides, in the opportunity I had of seeing the circumstance which I speak of, the surface of the sea was smooth and its waves not much moved, because the wind does not intermeddle with the earthquakes. The third remark is, that if the cavern of the earth where this subterraneous fire is locked up, has a direction from north to south, and if the town is parallelly situated in its length from north to south, all the houses are overthrown; whereas, if this vein or cavern executes its effect by the breadth of the town, the earthquake makes less havock." See Gentils voyages round the World, vol. I. page 172, &c.

In countries subject to earthquakes it happens, when a new volcano is formed, earthquakes cease, and are only felt in the violent eruptions of the volcano, as is observed in the island of St. Christopher. See Abridgment of Phil. Trans. vol. II. page 392.

The enormous ravages produced by earthquakes have made some naturalists think that the mountains and inequalities of the surface of the globe were only

ly the refult of the effects of the action of fubterraneous fires, and that all the irregularities we remark on the furface of the earth muft be attributed to the violent fhocks which they have produced: this, for example, is the opinion of Mr. Ray, he thinks that all mountains have been formed by earthquakes, or the explofion of volcanos, as mount Cineris, the new ifland near Santorino, &c. but he has not carefully remarked that thefe flight elevations formed by the eruption of a volcano, or by the action of an earthquake, are not internally compofed of horizontal ftrata, as all other mountains are; for by digging in mount Cineris, we meet with calcined ftone, cinders, burnt earths, machefer, pumice ftones, &c. all mixed and confounded in a heap. Befides if earthquakes and fubterraneous fires had produced the great mountains of the earth, as the Cordilleros, mount Taurus, the Alps, &c. the prodigious force which might have raifed thefe enormous maffes might at the fame time have deftroyed a great part of the furface of the globe, and the effect of the earthquake would have been of inconceivable violence, fince the moft famous earthquakes of which hiftory makes mention of have not had fufficient power to form mountains: for example, in the time of Valentine I. an earthquake happened, which was felt throughout all the known world, as Ammianus Marcellinus relates, lib. xxvi. cap. 14, and yet there was no mountain thrown up by this great earthquake.

It is neverthelefs certain that by calculation, we might be able to find that an earthquake violent enough to throw up the higheft mountains, would not be fufficient to diforder the reft of the globe.

For fuppofing for a moment, that the chain of the higheft mountain which croffes South America from the Magellanic lands to the mountains of new

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Grenada, and to the gulph of Darien, was all at once produced by an earthquake, and let us ſee by calculations the effect of this exploſion. This chain of mountains 1700 leagues in length and commonly forty in breadth, comprehending the Sieras, which are not ſo lofty as the Andes. The ſurface of this ground is therefore 68000 leagues ſquare; I ſuppoſe that the thickneſs of the matter diſplaced by the earthquake, is about a league, that is to ſay, that the height of theſe mountains taken from the top to the bottom, or rather to the caverns which in this hypotheſis muſt ſupport them, is only one league, which will be readily granted me; then I ſay, that the power of an exploſion or of an earthquake, will have raiſed a quantity of earth equal to 68000 cubical leagues to a league in height. Now the action being equal to the reaction, this exploſion will have communicated the ſame quantity of motion to the reſt of the globe, but the whole globe 12 milliards 310 millions, 563000801 cubical leagues from which ſubſtracting 68,000, there remains 12 milliards 300 millions 455000801 cubical leagues, the quantity of which motion will be equal to that of 68000 cubical leagues raiſed a league high: from whence we perceive, that the force which will have been great enough to diſplace 68000 cubical leagues and impel them on, will not have diſplaced an inch of the globe.

There would therefore be no abſolute impoſſibility to ſuppoſe that mountains have been raiſed by earthquakes, if their external compoſition as well as their external form, were not evidently the work of the ſea. The internal part is compoſed of regular and parallel ſtrata, filled with ſhells: the external has a figure whoſe angles are every where correſpondent: is it credible then that this uniform compoſition and this regular form have been pro-

produced by irregular ſhocks and ſudden exploſions.

But as this opinion has prevailed among ſome philoſophers, and as it appears to us that the nature and effects of earthquakes are not well underſtood, we think it neceſſary to give ſome ideas on that point which may ſerve to clear up this matter.

The earth having undergone great changes on its ſurface, we find even at conſiderable depths, holes, caverns, ſubterraneous rivulets and void places which ſometimes communicate by clifts, &c. there are two kinds of caverns, the firſt are thoſe produced by the action of ſuberraneous fires and volcanos ; the action of the fire uplifts, burns and throws out to a diſtance the matters that are above, and at the ſame time divides and deranges thoſe which are on the ſide, and thus produces caverns, grottos, holes, and anfractuoſities, but this is generally found only in the environs of lofty mountains, where volcanos are and theſe kind of caverns produced by the action of the fire are more rare than caverns of the ſecond kind, which are produced by water. We have obſerved that the different ſtrata which compoſe the terreſtrial globe on its ſurface, are all interrupted by perpendicular clifts, the water produced by rain and vapours deſcend through theſe perpendicular clifts, collect under the clay and form ſprings and rivulets ; by their natural motion they ſeek out all the little cavities and vacancies and always incline to flow and open roads, till they find a vent, carrying along with them at the ſame time ſand, earth, gravel and other matters they can divide, and by degrees form roads ; in the internal part of the earth they form kinds of ſmall trenches or channels which ſerve them for a bed ; at laſt, they iſſue forth either at the ſurface of the earth, or in the ſea, in the form of ſprings ; the matters which they carry along with them, leave

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vacancies whofe extent may be very confiderable, and thefe form grottos and caverns, the origin of which, as has been obferved, is quite different from that of caverns produced by earthquakes.

There are two kinds of earthquakes, the one caufed by the action of fubterraneous fires, and the explofion of volcanos, which are only felt at fmall diftances, and at the time when volcanos act, or before they open; when the matters which form fubterraneous fires, ferment, heat and inflame, the fire makes an effort on every fide, and if it does not find a natural vent, it raifes the earth and forms itfelf a paffage by throwing it out, which produces a volcano, whofe effects are repeated and laft in proportion to the quantity of inflammable matters. If the quantity of matters which take fire, is not confiderable, a commotion or an earthquake may enfue, without a volcano being formed. The air produced and rarified by the fubterraneous fire, may alfo find fmall vents, by which it will efcape, and in this cafe there will be only a fhock without any eruption or volcano: but when the inflamed matter is in a great quantity and confined by folid and compreffed matters, then a commotion and volcano arifes; but all thefe commotions form only the firft kind of earthquakes, and can only fhake a fmall fpace of ground. A very violent eruption of mount Etna will caufe, for example, an earthquake throughout the whole ifland of Sicily; but it will never extend to the diftance of three or four hundred leagues. When any new fire mouths are formed in mount Vefuvius, there are earthquakes at Naples and in the neighbourhood of the volcano: but thefe earthquakes have never fhook the Alps, and are not communicated into France or to other countries remote from Vefuvius, therefore the earthquakes produced by the action of volcanos, are limited to a fmall fpace, it is properly the effect of the re-acti-

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on of the fire; and they ſhake the earth, as like the explosion of a powder magazine produces a ſhock and an earthquake perceptible at many leagues diſtance.

But there is another kind of earthquake very different in its effects, and perhaps for its cauſes, there are earthquakes which are felt at great diſtances and which ſhake a long courſe of ground, without any new volcano or eruption appearing, we have examples of earthquakes which are felt at one and the ſame time in England, France, Germany, and even in Hungary; theſe earthquakes always extend much more in length than breadth, they ſhake a zone of ground with greater or leſs violence in different places and are almoſt always accompanied with a rumbling noiſe like that of a coach that rolls o'er the ſtones with rapidity.

To underſtand rightly what may be the cauſes of this kind of earthquake, it muſt be remembered that all inflammable matters capable of exploſion, produce like gunpowder, by inflammation, a great quantity of air: that this air produced by fire is in a ſtate of very great rarefaction, and that by a ſtate of compreſſion in which it is found in the bowels of the earth, it muſt produce very violent effects. Let us therefore ſuppoſe that at a very conſiderable depth, as at about one or two hundred fathoms, pyrites and other ſulphureous matters are to be met with, and that by the fermentation produced by the filtration of the water, or other cauſes, they inflame; and let us ſee what muſt happen: at firſt theſe matters are not diſpoſed regularly by horizontal ſtrata, as the more ancient matters are, which have been formed by the ſediment of the waters, on the contrary, they are formed in perpendicular ſtrata, in caverns at the foot of theſe clefts and in other parts where the water

can act and penetrate. These matters inflaming, will produce a great quantity of air, the spring of which compressed in a small space, like that of a cavern, will not only shake the upper ground, but will seek out for roads to escape and set itself at liberty. The roads which offer themselves, are caverns and trenches formed by the water and subterraneous rivulets; the rarefied air will precipate with violence into all those passages which are open, and will form a strong wind in these subterraneous roads, the noise of which will be heard at the surface of the earth, accompanied with shocks, &c. this subterraneous wind produced by the fire will extend as far as the cavities or subterraneous cavities, and will cause an earthquake so much the greater or less as it is distant from the vent and finds passages of a larger or lesser extent: this motion being made longways the shock will be the same and the earthquake will be felt throughout a long zone of ground: this air will not produce any eruption nor volcano, because it will find sufficient space to extend in, or rather because it will have found vents and issue forth in form of wind and vapour; and if we even should not allow that there in fact exist subterraneous roads by which the air and subterraneous vapours can pass, it may well be conceived that in the place where the first explosion is made, the ground being lifted up to a considerable height, it is necessary that the most adjoining to this spot, divides and splits in an horizontal manner to follow the motion of the first, which is sufficient to form roads which may communicate the motion from one to the other to a great distance and this explanation agrees with every phenomena. It is not at the same moment nor hour that an earthquake is felt in two distant places; for example, at one or two hundred leagues distance. There is no

no fire nor eruptions from those earthquakes which are heard at a distance, and the noise which always accompany them marks the progressive motion of this subterraneous wind. We can also confirm what is just said, by connecting it with two other circumstances: it is well known that mines exhale vapours, independent of the wind produced by the current of the water; we often see currents of unhealthy air and suffocating vapours: it is also known that there are holes, abysses and deep lakes in the earth which produce winds, like the lake Boleslaw in Bohemia, which we have already spoken of.

All this being clearly understood, I do not rightly see how it can be imagined that earthquakes produce mountains, since the cause itself of these earthquakes are mineral and sulphureous matters which are generally found only in perpendicular clefts of mountains and other cavities of the earth, the greatest number of which have been produced by the water; that this matter by inflaming produces only a momentanous explosion and a violent wind which follows the subterraneous roads of the water; that the duration of the earthquakes is in fact only momentanous at the surface of the earth and that consequently their cause is only an explosion and not a durable fire; and that in short, these earthquakes which shake a great space, and which extend to a very considerable distance, very far from raising chains of mountains, do not throw up the earth in any sensible quantity, and do not produce the smallest hills throughout their whole extent.

Earthquakes are in fact much more frequent in parts where volcanos are, than in other places, as in Sicily and Naples, it is known by observations made at different times, that the most violent earthquakes happen in the time of the greatest eruptions of vol-

volcanos; but these earthquakes are not those which extend the farthest nor can they ever produce a chain of mountains.

It has been sometimes observed that the matters thrown out of Mount Etna, after having lain for many years and afterwards moistened with the rain, have reflamed and thrown out flames with a very violent explosion, which even produced a slight shock.

In a a furious eruption of Etna in 1669, which began the 11th of March, the summit of the mountain sunk considerably, as all who saw the mountain before this eruption, were sensible of. (See Transf. Phil. Abridged. Vol II. page 387; which proves the fireof a volcano comes rather from the top than from the internal depth of the mountain. Borelli is of the same opinion, and says precisely, " That the fire of volcanos does not proceed from the center, nor from the foot of the mountain, but that on the contrary it issues from the summit, and only flames at a small depth." (See Borelli, de Incendiis montis Etna.)

Mount Vesuvius in its eruptions has thrown out a great quantity of boiling water; M. Ray, whose opinion is,that the volcanean fire proceeds from a very great depth, says that is the water of the sea which communicates to the internal caverns of the foot of this mountain he gives as a proof of it, the dryness and aridity of the summit of Vesuvius and the motion of the sea which in the time of these violent eruptions, retreats from the coasts, and diminishes to the point of leaving the bay of Naples sometimes dry: but if these facts were very true they would not prove in a solid manner that the volcanean fire proceeds from a great depth; for the water which is thrown out is certainly the rain water which penetrates through the clefts and collects in the cavi-

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ties of the mountain; we ſee water and rivulets flow from other lofty mountains, and as they are hollow and have been more ſhaken than other mountains, it is not aſtoniſhing that the water collects in the caverns in their internal part, and that theſe waters are thrown out in the time of eruptions with other matters; with reſpect to the motion of the ſea, it proceeds ſolely from the ſhock communicated to the waters by the exploſion, which muſt cauſe them to flow or reflow according to different circumſtances.

The matters which volcanos throw out, generally come forth in the form of a torrent of melted minerals, which inundates all the environs of theſe mountains; theſe rivers of liquified matters extend even to conſiderable diſtances, and by cooling, theſe matters in fuſion, form horizontal or inclined ſtrata, which for poſition are like the ſtrata formed by the ſediment left by the waters: but it is very eaſy to diſtinguiſh the ſtrata produced by the expanſion of matters thrown out by volcanos, from thoſe which the ſediment of the ſea have for their origin. 1. Becauſe theſe ſtrata are not throughout of an equal thickneſs: 2. becauſe they contain only matters which are evidently perceived to have been calcined, vitrified, or melted, and becauſe they do not extend to any great diſtance. As there are a great number of volcanos at Peru, and as the foot of moſt of the mountains of the Cordillero's is covered with theſe matters thrown out by theſe volcanos, it is not aſtoniſhing that marine ſhells are not met with in the ſtrata of the earth, having been calcined and deſtroyed by the fire, but I am perſuaded if we dig into the argilaceous earth, which, according to M. Bouguer, is the common earth of the valley of Quito, ſhells are found there, as they are in other places; by ſuppoſing this earth to be purely agila-

ceous and not like that at the foot of mountains, a ſoil formed by the matters thrown out of the volcano.

It has often been aſked why volcanos are all met with at the top of mountains? I think I have partly given a ſatisfactory anſwer to this queſtion in the preceeding diſcourſe, but as I have not entered into a ſufficient detail of it, I have thought it my duty not to finiſh this article without farther developing what I have ſaid on this ſubject.

The peaks or points of mountains were formerly covered and ſurrounded with the ſand and earth which the rain waſhes along with it into the vallies, and has left only the rocks and ſtones which forms the nucleus of the mountain. This being left bare and uncovered to the foot, will have been ſtill worn by the injuries of the air, the froſt will have looſened the large and ſmall parts which have rolled to the bottom, at the ſame time it has ſplit many rocks at the ſummit of the mountain, thoſe which form the baſe of this ſummit being left bare, and no longer ſupported by the earth which ſurrounded them, will have given way a little, and by dividing one from the other formed ſmall intervals: this ſhock of the lower rocks cannot be made without communicating a greater motion to the upper, and by that means ſplitting or dividing from each other. In this nucleus of the mountain there will be formed an infinity of ſmall and large perpendicular clefts, from the ſummit to the baſe of the lower rocks: the rain will have penetrated into all theſe clefts and looſened in the inſide of the mountain all the mineral parts and other matters that it could carry away or diſſolve, they will have formed pyrites and other combuſtible matters, and when by length of time, theſe matters were accumulated in great quantity they have fermented, and by inflaming produced exploſion, and other effects of volcanos; perhaps like-

likewiſe, within the mountains there were maſſes of theſe mineral matters already formed before the rain could penetrate therein: as ſoon as holes and clefts were made which gave paſſage to the water and air, theſe matters inflamed and formed a volcano: none of theſe motions could be made in plains ſince all is at reſt and nothing can be diſplaced, it is not ſurprizing that there are therefore no volcanos in plains, and that they in fact are found only in high mountains.

When coal mines are opened, which are generally met with in argilaceous earth at a great depth, it ſometimes happens that theſe matters have taken fire; there are even mines of coal in Scotland, Flanders, &c which have burnt for a number of years. The Communication of the air ſuffices to produce this effect, but theſe fires which are lighted in theſe mines, produce only ſlight exploſions and do not form volcanos, becauſe all being ſolid and full in theſe places, fire cannot be excited, like that of volcanos in which there are cavities and void places where the air penetrates, which muſt neceſſarily extend the conflagration and augment the action of the fire, to the point in which we ſee it when it produces the terrible effects we have ſpoken of.

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ARTICLE XVII.

Of New Islands, Caverns, Perpendicular Clefts, &c. &c.

NEW islands are formed in two manners, either suddenly by the action of subterraneous fires, or gently by the deposit of mud. We shall first speak of those which owe their origin to these two causes. Ancient historians and modern travellers relate facts on this subject which can scarcely be doubted. Seneca assures us, that in his time the island Therasia appeared all at once to the sight of mariners. Pliny relates that formerly, there were thirteen islands in the Mediterranean, which sprung at one and the same instant out of the sea, and that Rhodes and Delos are the principal of these thirteen new islands; but, it appears by what he says of them, and by what likewise Ammian Marcellinus, Philo and others assert, that these thirteen islands were not produced by an earthquake, nor by any subterraneous explosion, they were formerly hid under water and the sea lowering left, they say, these islands uncovered. Delos had even the name of *Pelagia* given to it, as having formerly belonged to the sea. We therefore are not certain whether we should attribute the origin of these thirteen islands to the action of subterraneous fires, or to some other cause which might have produced a sinking and diminution of the water in the Mediterranean. But Pliny relates, that the island Hiera near Therasia, has been formed of ferruginous masses, and earth thrown from the bottom of the sea: and in chapter 89, he speaks of many other islands, formed after the like man-

manner; on this ſubject we have more certain facts of later date.

The 23d of May 1707, at the ſun's riſing this iſland of Theraſia or Santorin, was ſeen like a floating rock in the ſea; ſome perſons who were curious went near it, and found this ſhoal which had iſſued from the bottom of the ſea, to increaſe under their feet, and they brought with them the pumice ſtone and oyſters which the rock ſtill had attached to its ſurface. There was a ſlight earthquake at Santorin two days before the growth of this ſhoal; this new iſland increaſed conſiderably till the 14th of June without any accident, and was then half a mile round and from twenty to thirty feet high, the earth was white and bordered a little argilaceous; but after that the ſea was troubled more and more, vapours aroſe which infected the iſland Santorin and the 16th, 17th or 18th of July, rocks were ſeen to iſſue at one time from the bottom of the ſea, all which united and formed like one rock. All this was done with a diſmal noiſe which continued upwards of two months, with flames which roſe from the new iſland; it ſtill kept increaſing in circumference and height, and the exploſions always threw out rocks and ſtones more than ſeven miles diſtance. The iſland Santorin itſelf, has been deemed among the ancients as a modern production, and in 1726, 1427, and 1573, it has increaſed in growth, and ſmall iſlands have been formed near Santorin. See the Hiſt. of the Acad. 1708, p. 23, &c. The ſame volcano which in the time of Seneca, formed the iſland of Santorin, in the time of Pliny produced that of Hiera or Volcanello, and in our time the above ſhoal has been formed.

The 10th of October 1720, near the iſland Terceria, a very conſiderable fire aroſe out of the ſea; mariners having approached it by the orders of the

governor, perceived the 19th of the ſame month, an iſland which appeared only as fire and ſmoke, with a prodigious quantity of cinders thrown to a diſtance, as if cauſed by the force of a volcano, with a report like that of thunder. An earthquake happened at the ſame time which was felt in the circumjacent places and a great quantity of pumice ſtones were obſerved on the ſea, eſpecially around the new iſland, theſe pumice ſtones ſwam and ſometimes a great quantity was found in the midſt of the high ſeas. See Philoſ. Tran. Abridg. vol. VI. part ii. p. 154. The Hiſt. of the Academy, anno 1721, ſays on this event, that after an earthquake in the iſland of St. Michael, one of the Acoras, there appeared between this iſland Tercera a torrent of fire which gave birth to two new ſhoals, p. 26. In the volcano of the following year 1722, we meet with the following detail:

" M. de Liſle, has informed the Academy of many particularities concerning the new iſland between the Acoras, which he extracted from a letter of M. de Montagnac, conſul at Liſbon."

" A veſſel which was moored the 18th of September 1721, before the fortreſs of the town of St. Michael, which is in the iſland of the ſame name, and the following is what was learnt from the pilot."

" On the 7th of December 1720, at night there was a great earthquake in Tercera and St. Michael, about eighteen leagues apart, between which the new iſland ſprung up: it was remarked at the ſame time that the point of iſland Pico, which was thirty leagues diſtant and which before threw out fire, was ſunk and emitted none; but the new iſland kept throwing out a thick ſmoke and it was effectively ſeen from the veſſel M. de Montignac was in. The pilot aſſured us that he had gone round the iſland

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in a boat, rowing as near it as poſſible. On the ſouth ſide he threw the line ſixty fathom deep, without touching any bottom; on the weſt ſide, the water was found greatly changed, being of a fair blue and green, and which extended two-thirds of a league, and ſeemed ready to boil. On the north weſt, the part from which the ſmoke iſſued, he found fifteen fathom water, the bottom being a thick ſand; he threw a ſtone into the ſea, and ſaw in the part where it fell, the water to boil and bubble with impetuoſity: the bottom was ſo hot that it twice melted the greaſe at the bottom of the ſounding lead; the pilot obſerved on that ſide the ſmoke to iſſue from a ſmall lake bounded by a ſand bank; the iſland is almoſt round and high enough to be perceived at the diſtance of ſeven or eight leagues in clear weather.

"It has ſince been learnt from a letter of M. Adrian conſul of the French nation, in the iſland of St. Michel, dated March 1722, that the new iſland had conſiderably diminiſhed, and that it was almoſt level with the water, ſo that there was every appearance to think it would not laſt long."

We are therefore aſſured by theſe facts, and by a great number of others of a ſimilar nature, that even underneath the ſea, inflammable matters incloſed in the bowels of the earth, act and cauſe violent exploſions. The places where this happens are kinds of volcanos which might be termed *marine*: and which differ from common volcanos only by the ſhortneſs of the duration of their action, and the unfrequency of their effects: for it is readily conceived that the fire having opened itſelf a paſſage, the water muſt penetrate therein and extinguiſh it: the new iſland muſt conſequently leave a void ſpace which the water muſt fill, and this new earth, which is only compoſed of matters thrown out by the marine volcano, muſt

muſt in every thing reſemble mount Cineris, and other eminences which terreſtrial volcanos have formed in many places: now in the time of the diſplacement cauſed by the violence of the explosion, and during this motion the water will have penetrated into moſt of the vacant places, and for a time will have extinguiſhed this ſubterraneous fire. This apparently is the reaſon that theſe ſub-marine volcanos act ſeldomer than other volcanos, although the cauſes of both are the ſame, and the matters which produce and feed theſe ſubterraneous fires, may be found under the earth covered by the ſea, in as great a quantity as under the earth which lies open to the air and uncovered.

Theſe are the ſame ſubterraneous or ſub-marine fires, which are the cauſe of all thoſe ebullitions of the ſea, which ſailors have remarked in divers places, and of the water ſpouts we have before-mentioned; they likewiſe produce ſtorms and earthquakes which are not leſs ſenſible on the ſea, as on the land. Theſe iſlands which have been formed by theſe ſub-marine volcanos, are generally compoſed of pumice-ſtone and calcined rocks, and theſe volcanos produce, like thoſe of the land, very violent earthquakes and commotions.

Fires have been alſo often ſeen on the ſurface of the water; Pliny tells that the lake Thraſimenia appeared inflamed over all its ſurface. Agricola relates that when a ſtone is thrown into the lake Denſtad in Thuringia, it appears as it deſcends in the water, like a flaſh of fire.

In ſhort, the quantity of pumice ſtones which travellers aſſure us they have met with in many parts of the ocean, and the mediterranean, proves that there are volcanos at the bottom of the ſea, ſimilar to thoſe we are acquainted with, and which do not at all differ, neither by the matters they caſt out, nor

nor by the violence of the explosion, but solely by the rarity, and shortness of duration of their effects; all, even volcanos are met with at the bottom of the sea, as the surface of the earth.

If we even pay attention thereon, we shall find many connections between land volcanos and sea volcanos; both the one and the other are found at the summit of mountains; the islands of Acoras and those of the Archipelago are only peaks of moun-some which rise above the water and others are underneath. By the account of the new island of the Acoras we see, that the part from whence the smoke issued was only 15 fathom under water, which being common the depth of the ocean, proves that even this part is the summit of a mountain; as much may be said of the island Sanctorin, it was not a great depth, since oysters were found attached to the rocks which rose up. It appears also that these marine volcanos, have like those of the land, some subterraneous communications, since the summit of the volcano of Saint George, in the island Pico, sinks when the new island of the Acoras rises: it must also be observed that these new islands never appear but after the old ones, and that we have no example of new islands having arisen in the high seas; we must therefore look on the soil where they are, as a continuation of that of the adjacent islands, and when these islands have volcanos, it is not astonishing that the ground adjacent, contain matters proper to form them, and that these matters inflame, either by fermentation alone, or by the action of subterraneous winds.

On the whole, the islands produced by the action of fire and earthquakes are but few and these events are seldom; but there are an infinite number of new islands produced by the mud, sand and earth, which the rivers, or the sea carry and transport into dif-

different places. At the mouth of all rivers, maſſes of earth and banks of ſand forms, whoſe extent often becomes conſiderable enough to form iſlands of a moderate ſize. The ſea retiring from certain coaſts, leaves the parts higheſt from the bottom naked, which forms ſo many new iſlands, and ſo likewiſe by extending itſelf on certain ſhores, it covers the loweſt parts, and leaves the higheſt, which it could not ſurmount, apparent above the ſurface of the water, which forms ſo many more iſlands, in conſequence of which it is remarked that there are very few iſlands in the middle of the ſea, and that they are almoſt all in the neighbourhood of the continents, where the ſea formed them, either by retreating from or approaching towards theſe different countries.

Water and fire whoſe natures are ſo different, and even ſo contrary, produce ſimilar effects, or at leaſt thoſe which appear to us as ſuch ; independent of the particular productions of theſe two elements, ſome of which bear ſo ſtriking a reſemblance, as to be miſtaken for each other, as glaſs and chryſtal, natural and fictitious antimony, the natural matters of mines, and thoſe artificially made by fuſion, &c. There are in nature an infinity of great effects produced by water and fire, which are ſufficiently ſimilar, ſo as ſcarcely to be diſtinguiſhed. Water, as has been obſerved, has produced mountains and formed moſt iſlands. There are likewiſe caverns, clefts, holes, gulphs, &c. ſome owe their origin to ſubterranean fires, and others to waters, as well ſubterranean as ſuperficial.

Caverns are met with in mountains, and few or none in plains : there are many in the Archipelago iſland, and in many other iſlands, and becauſe they are in general only above the mountains ; caverns are formed like precipices, by the ſinking of rocks, or

or like abyſſes, by the action of the fire: for to form a cavern of a precipice or abyſs, we muſt only ſuppoſe the rocks contributed thereto, by making a vault, which muſt very often happen when come to be ſhaken and diſlodged. Caverns may be produced by the ſame cauſes which produce holes, the ſhaking and ſinking of the earth, which cauſes are the exploſion of volcanos, the action of ſubterranean vapours and earthquakes; for they occaſion caverns, holes, and anfractuoſities of every kind to be formed by their ſhocks and deſtruction.

Saint Patrick's cavern in Ireland is not ſo conſiderable as it is famous, it is the ſame with the Dog's Grotto in Italy, and that which throws out fire, in the mountain of Benigauzeval in the kingdom of Fez. In the county of Derby in England, there is a very conſiderable large cavern, much larger than the famous cavern of Beauman, near the Black Foreſt in the country of Brunſwick. I have been informed by a perſon as reſpectable for his merit as his name (Lord Morton) that this large cavern, called the *Devil's Hole*, at firſt preſents a very conſiderable opening, like that of a large church door: that through this opening a large rivulet flows; that in advancing the vault of the cavern grows lower, ſo much, that in a certain part of it, perſons who are deſirous of continuing their road, are obliged to get into very flat boats, and lay on their backs to paſs under the vault of the cavern, which in that part is ſunk ſo greatly, that the water almoſt touches the vault; but after having paſſed this part of the vault, the vault riſes and the paſſage on the river is free till the vault ſinks again, and touches the ſuperficies of the water, where the cavern ends, and the ſource of the rivulet which iſſues from it, increaſes conſiderably in a certain time: and brings and heaps up a great quantity of ſand in one part of the cavern, which

which is formed like an alley, whofe direction is different from that of the principal cavern.

In Carniola is a cavern Potpechio, which is very fpacious, and in which a large fubterraneous lake is found. Near Adelfperg is a cavern in which we may travel two German miles, and where very deep precipices are to to be met with. (See Act. erud: Lips. anno 1689, page 558. There are alfo large caverns and beautiful grottos under the mountains of Mendip in Wales; mines of lead are found near thefe caverns and whole oaks at fifteen fathom depth. In the county of Gloucefter there is a very large cavern called *Pen Parkhole*, at the bottom of which there is a depth of water thirty fathom, and mines of lead are alfo found here.

The Devil's hole and other caverns therefore from whence iffue large fprings or rivulets, have been hollowed out and formed by the water which has brought along with it, fand and other divided matters that are found among the rock and ftones, and we fhould be perfectly right in attributing the origin of thefe caverns to earthquakes and other natural fhocks.

One of the moft remarkable and largeft caverns known, is that of Antiparos, an ample defcription of which has been given us by M. de Tournefort. We enter a ruftic cavern about thirty feet broad, divided by fome natural pillars on the right, the ground is a gentle flope, and afterwards to the bottom of a more rough inclination for about twenty feet in length; this is the paffage to go to the grotto or internal cavern, which is very dark, and which cannot be entered without ftooping and the affiftance of torches: we directly defcend into an horrible precipice by the affiftance of a rope, which is carefully faftened at your entrance, one fide, into another ftill more frightful, the borders of which are very flippery

pery, with dark abyſſes on the left. On the borders of theſe gulphs a ladder is placed, by means of which we mount with trembling, a rock perpendicularly cut, and continue to go through places ſomewhat leſs dangerous: but, in the very inſtant when we think ourſelves in a good path, the moſt horrible obſtruction ſtops us ſhort, and the curious naturaliſt would be in danger of breaking his head, did not the guide forewarn him: to get free of this you are obliged to crawl on your hands and knees the length of a large rock, and deſcend a ladder brought with you on purpoſe: when you are at the bottom of the ladder, you ſtill crawl over the rocks for ſome time and at laſt reach the grotto. It is computed to be three hundred fathom deep from the ſurface of the earth, but the grotto appears to be forty fathom high by fifty broad, it is filled with large beautiful ſtalactites of various forms, as well on the roof of the vault as at the bottom. See the Voyage de Levant, page 188, &c.

In part of Greece called *Livadia* (the *Achaia* of the ancients) there is a large cavern in a mountain which was formerly very famous for the oracles of Trophonius, between the lake Lividia and the adjacent ſea, which in the neareſt part is forty miles over; there are forty ſubterranean paſſages acroſs the rock under a lofty mountain, through which the waters of the lake flows. See Gordon's Geography, 1733, page 179.

In all volcanos, in all countries which produce ſulphur and in all theſe which produce earthquakes, there are caverns. The ground of moſt of the Archipelago iſlands are cavernous, that of the iſlands of the Indian ocean, principally that of the Molucca's, appear only to be ſupported by vaults and cavities. That of the Acoras, the Canaries, the iſlands of Cape Verd, and in general the ground of almoſt

every ſmall iſland, is internally hollow and cavernous in many parts, becauſe theſe iſlands are, as we have obſerved, only points of mountains where conſiderable ebulitions are made, either by the action of volcanos, either by that of the water, froſts or other injuries of the weather. In the Cordilleros, where there are many volcanos, and where earthquakes are frequent, there is alſo a great number of caverns, as there is likewiſe in the volcano of the iſland of Banda, in mount Azarat which is an antient volcano, &c.

The famous labyrinth of the iſland of Candia, is not the work of nature alone, M. de Tournefort aſſures us, that it has been greatly worked upon by men, and it muſt be ſuppoſed that this cavern is not the only one which has been augmented by human labour, new ones are every day formed by digging mines and quarries, and when they are abandoned for a long time, it is not very eaſy to diſcover whether theſe excavations have been the productions of nature or formed by the hands of man. We know of quarries of conſiderable extent; for example that of Maeſtricht, where it is ſaid 50,000 men may conceal themſelves and which is ſupported by upwards of 1000 pillars twenty or twenty-four feet high. The thickneſs of the earth and rock which is above is more than twenty-five fathom. In many parts of this quarry there is water and ſmall ponds where cattle may be watered, &c. See Abridg. Phil. Tranſ. vol. II. p. 463.

The ſalt mines in Poland form ſtill greater excavacations than the above, There are generally vaſt quarries near large towns, but we do not here ſpeak of them in general: beſides the labour of man however great it may be, will ever hold but a ſmall place in the hiſtory of nature.

Volcanos and waters which produce caverns inter-

ternally, form alſo external clefts, precipices and abyſſes. At Cajeta in Italy, there is a mountain which formerly has been ſeparated by an earthquake, in a manner ſo as to appear as if the diviſion was made by the hand of man: we have already ſpoken of the matters of the iſland of Machian, of the abyſs of mount Azarat, of the gate of the Cordilleros, and that of Thermopyle, &c. To theſe may be added, the gate of the mountain of Froglodytes in Arabia; which nature only ſketched out and which Victor Amadeus cauſed to be finiſhed. Water as well as ſubterranean fires produce conſiderable ſinkings of the earth, falls of rocks, overthrows of mountains of which we can give many examples.

In the month of June 1714, a part of the mountain of Diableret in Valois, fell ſuddenly and between two and three o'clock in the afternoon: the ſky was very ſerene, the mountain was of a conical figure, and deſtroyed fifty-three huts belonging to the boors, and cruſhed to death fifteen people, and more than an hundred head of large and much more of ſmall cattle; covering a ſquare league with the ruins it occaſioned. A profound darkneſs was cauſed by the duſt, the heaps of ſtones thrown together were above thirty perches. Theſe heaps ſtopt the current of the water which formed new and very deep lakes. In all this there was not the leaſt trace of bituminous matter, ſulphur, lime, nor conſequently any ſubterranean fire and apparently the baſe of this great rock was worn away or periſhed and reduced to duſt." Hiſtoire de l'Academie des Sciences, anno 1715, p. 4.

We have a remarkable example of theſe ſinkings near Folkſtone, in the county of Kent: the hills in its environs have ſunk gradually by an inviſible motion and without any earthquake. Theſe hills internally are rocks of ſtone and chalk, by this ſinking

ing they have thrown into the ſea rocks and earths which are adjacent to it. The relation of this may be ſeen in the Abridgement of the Philoſophical Tranſ. vol. VI. p. 250.

In 1618, the town of Pleurs in Valtelino was buried under the rocks at the bottom which it was ſituate. In 1678, there was a great inundation in Gaſcony, cauſed by the ſinking of ſome pieces of mountains in the Pyrenees, which cauſed the water to ſpring forth, which was contained in the ſubterranean caverns of theſe mountains. In 1680 there happened a ſtill greater in Ireland which alſo had the ſinking of a mountain into caverns filled with water for its cauſe. We may eaſily conceive the cauſe of all theſe effects: it is well known there are ſubterranean waters in an infinity of places, theſe waters carry off by little and little the ſand and earth over which they paſs, conſequently by degrees deſtroy the bed of earth on which the mountain reſts, and this bed of earth which ſerves it for a baſe, being more deficient on one ſide than on the other, the mountain of courſe muſt be overthrown, or if this baſe falls every where alike, the mountain will ſink and not be overthrown.

After having ſpoken of the ſinkings, and of all which happens, as I may ſay, only by accidents in nature, we ought not to paſs over in ſilence a matter which is more general, common and antient: which is the perpendicular clefts found throughout the ſtrata of the earth; theſe clefts are perceptible and eaſy to be diſcovered, not only in the rocks, quarries of marble and ſtone, but, alſo in argilaceous and earths of all kinds which have not been ſtirred, and they may be obſerved in all cuts that are a little deep in the earth and in all caverns and excavations: I call them *perpendicular clefts*, becauſe it is only but by accident that they are oblique, as the hori-

horizontal ſtrata are inclined only by accident. Woodward and Ray ſpeak of theſe clefts, but in a confuſed manner, and they do not term them perpendicular clefts, becauſe they thought they might be indifferently oblique or perpendicular, and no author has explained the origin of them. Nevertheleſs, it is apparent that theſe clefts have been produced, as we have obſerved in the preceeding diſcourſe, by the dryneſs of matters which compoſe horizontal beds: in whatſoever manner this dryneſs happens, it muſt have produced perpendicular clifts; the matters which compoſe the ſtrata have not been able to diminiſh in volume, without ſplitting in a perpendicular direction to theſe ſtrata. Nevertheleſs, I comprehend under this name of perpendicular clefts, all natural ſeparations of rocks, whether they are met with in the original poſition, or whether they have ſlipt a little in their baſe and conſequently a little removed from each other. When ſome conſiderable motion happens to maſſes of rocks, theſe clefts are found obliquely placed, but this is becauſe the maſs is of itſelf oblique, and with a little attention it is always very eaſy to diſcover that theſe clefts are in general perpendicular to the horizontal ſtrata, particularly in quarries of marble, lime, ſtones, and all large chains of rocks.

Mountains internally are principally compoſed of ſtone and rocks, where different beds are parallel: between the horizontal beds ſmall ſtrata of a ſofter matter than ſtone is found, and the perpendicular clefts are filled with ſand, chryſtals, minerals, metals, &c. theſe laſt matters are of a more modern formation than that of the horizonal beds, in which we find ſea ſhells. The rains have by degrees looſened the ſand and the earth on the upper parts of the mountains, and have left the ſtone and other ſolid matter entirely naked, in which we readily diſtinguiſh

guiſh the horizontal ſtrata and perpendicular clefts: in plains, on the contrary, the rain water and floods having brought a conſiderable quantity of earth, ſand, gravel, and other broken matters, have formed ſtrata of turf, ſoft and diſſoluble ſtone, ſand and pebble and earth mixed with vegetables: theſe ſtrata contain no marine ſhells; or at leaſt, contain only fragments which have been detached from mountains with gravel and earth. We muſt carefully diſtinguiſh theſe new ſtrata from the old, where almoſt always a great number of entire ſhells are found placed in their natural ſituation.

If we obſerve the order and internal diſpoſition of matters in a mountain compoſed, for example of common ſtones or calcinable lapidific matters, we generally find a ſtrata of gravel under the vegetable earth; this gravel is of the nature and colour of the ſtone which predominates in this ground, and under the gravel we meet with ſtone: when the mountain is divided by ſome trench or deep cut, we eaſily diſtinguiſh all the banks and ſtrata of which it is compoſed. Each horizontal ſtratum is ſeperated by a kind of joint which is likewiſe horizontal, and the thickneſs of theſe banks or horizontal ſtrata generally increaſe in proportion as they lower; that is to ſay, farther from the ſummit of the mountain: theſe clefts are alſo perceived to divide all the ſtrata and cut them vertically. In common, the firſt ſtratum, the firſt bed which is met with under the gravel, and even the ſecond are only thinner than the beds which form the baſe of the mountain, but are alſo divided by perpendicular clefts, ſo wore that pieces of any length are not to be ſeen, but only the ſmall ſtony matter of theſe perpendicular clefts which are numerous at the ſuperficies and which perfectly reſemble the cracks of ground which are very dry, do not all reach, by far to the bott[illegible] inſenſibly diſ-

appear in proportion as they defcend, and at bottom are only a certain number of thefe perpendicular clefts, which divide the lower banks more than of the fuperficies, and are always thick than the upper bank.

Thefe beds of ftone, are often, as I have obferved, many leagues in extent without any interruption: we almoft always meet with the fame kind of ftone in the oppofite mountain, although divided from it, by a neok or valley, and the beds of ftone difappear only in places where the mountain finks and becomes level with fome large plain. Sometimes between the firft ftratum of vegetable earth and that of gravel, marle is found, which communicates its colour and other characters to the other two: then the particular clefts of the quarries which are beneath, are filled with this marle, which acquires an hardnefs almoft in appearance equal to that of ftone, but by expofing it to the air it crumbles, foftens and becomes ductile.

In moft quarries the beds formed on the upper part or fummit of a mountain, are foft ftone, and thofe which form the bafis of the mountain are hard; the firft is commonly white, of fo fine a grain as fcarcely to be perceived; the ftone becomes more grained and harder in proportion as it defcends, and the loweft ftone of the banks is not only harder than that of the upper beds, but it is alfo clofer, compact and heavier; its grain is fine and gloffy and often brittle and breaks as clear as flint.

The nucleus of a mountain is therefore compofed different beds of ftone, the upper part of which are of foft ftone and the lower of hard; the ftony nucleus is always broader at the bottom than at the top, we may attribute the caufe of it to thefe different degrees of hardnefs which we meet with in beds of ftone; for, as they become fo much the harder as they

they are farther removed from the ſummit of the mountain, it may be ſuppoſed that the currents and other motions of the waters which have hollowed the vallies and give a ſhape to the turnings of a mountain; will have laterally worked on the matters of which the mountain is compoſed, and will have worn them away ſo much the faſter as they were ſofter: ſo that the upper ſtrata being the moſt tender, will have ſuffered the greateſt diminution in their breadth and will have laterally been worked upon more than the reſt: the ſucceeding ſtrata will have reſiſted a little more, and thoſe of the baſe being more ancient, ſolid, and formed in a more compact and harder manner, will have been more in a condition than all the reſt to defend itſelf againſt the action of exterior cauſes, and they will have ſuffered little or no lateral diminution by the friction of the water. This is one of the cauſes to which the origin of the ſtone of mountains may attributed, this inclination will become ſtill leſs ſteep in proportion as the earth on the ſummit, and the gravel has run down and been waſhed away by the rain, and for theſe two reaſons, it is, that all hills and mountains which are compoſed of oily calcinable ſtone and other calcinable lapidific matters, have an inclination which is never ſo rapid as that of mountains compoſed of live rock and flint in large maſſes, which are generally cut regular from very conſiderable heights; becauſe, in theſe maſſes of vitrifiable matters, the upper beds as well as the lower, are of very great hardneſs, and that they all have alike reſiſted the action of the water, which could not wear them alike from top to bottom, and gave them conſequently a perpendicular, or nearly a perpendicular inclination.

When on the top of certain hills whoſe ſummit is flat, and of a pretty large extent, we at firſt meet

meet with hard ſtone under the ſtratum of vegetable earth, we ſhall remark, if we obſerve the environs of theſe hills, that what appears to be the ſummit of it, is not ſo in fact, and that this upper part of the hill is only the continuation of the inſenſible ſtone of ſome higher hill; for after having traverſed this ſpace of ground, we find other eminences which riſe higher, and whoſe upper ſtrata are ſoft ſtone and the lower hard; it is the prolongation of theſe laſt ſtrata that we meet with again at the top of the firſt hill.

When on the contrary, a quarry is opened near the ſummit of a mountain, and in ground which is not ſurmounted by any conſiderable height, generally only ſoft ſtone is dug out of it, and we muſt dig very deep to meet with hard ſtone. Banks of marble are never found but between theſe beds of of hard ſtone; theſe marbles are diverſely coloured by the metallic earths which the rain introduces into the ſtrata by infiltration, after having detached them from the other upper ſtrata; and it may be imagined that in every country where there is ſtone, marble would be found if dug for, deep enough to get at the banks of hard ſtone: *quoto enim loco non ſuum marmor invenitur?* ſays Pliny; this in fact is a much more common ſtone than it is thought to be, and which differs from other ſtones, only by the fineneſs of its grain, which renders it more compact and ſuſceptible of a brilliant poliſh, a quality eſſential to it, and from which it took its denomination from the ancients.

The perpendicular ſtrata of quarries and joints of beds of ſtone, are often filled and incruſted with certain concretions, which are ſometimes as tranſparent as chryſtal, of an irregular figure, ſometimes opaque and terrene: the water flows through the perpendicular clefts, and penetrates even the

compact coat of the ſtone; the ſtones which are porous, imbibe ſo great a quantity of water, that the froſt ſplits and divides them. The rain tranſuding the beds of a quarry, and during its ſtay in the beds of marle, ſtone, and marble, looſen the leſs adherent and fine molecules, and load themſelves with every matter they can take up or diſſolve. Theſe waters at firſt run along the perpendicular clefts, they afterwards penetrate between the beds of ſtone, and depoſit between the horizontal joints, as well as in the perpendicular clefts, the matters they have brought with them, and they form theſe different congelations according to the different matters which they have depoſited : for example, when theſe dribling waters tranſude thro' marle, chalk, or ſoft ſtone, the matter which they depoſit is likewiſe a very pure and fine marle, which generally enters in the perpendicular cleft of the rocks under the form of a porous ſoft ſubſtance, commonly very white and light, which naturaliſts have called *Lac lunce*, or *Medulla Saxi*.

Whence theſe ſtreams of water loaded with lapidific matter, flow through the horizontal joints of the beds, ſoft ſtone or chalk, this matter attaches itſelf to the ſuperficies of the blocks of ſtone, and forms there a ſcaly, light, white, and ſpongy cruſt; it is this kind of matter which ſome authors have named *Mineral Agaric*, by its reſemblance to vegetable agaric : but if the matter of the ſtrata has a certain degree of hardneſs, that is to ſay, if the beds of the quarry are of common hard ſtone, proper to make good lime, the fiiter being then more cloſe, the water will iſſue from it loaded with lapidific matter, purer, homogenous, and whoſe molecules can grain more exactly, and unite more intimately : and then there will be formed congelations which will nearly have the hardneſs of ſtone, and a little

little tranſparency, and we ſhall find on the ſuperficies of the blocks in theſe quarries, ſtony incruſtations unduloufly diſpoſed, which entirely fills the horizontal joints.

In grottos and cavities of rocks, which may be looked upon as the baſons of perpendicular clefts, the diverted direction of the ſtreams of water, which convey the lapidific matter, give to the concretion which reſult therefrom, different forms, which are attached to the vault, or hollow and white cylinders, formed by the almoſt concentrical ſtrata to the axis of the cylinder; and theſe congelations ſometimes deſcend to the earth, and form in theſe ſubterraneous places, pillars, and a thouſand other figures, as uncouth and ridiculous as the names which naturaliſts have been pleaſed to give them, ſuch as, *Slatactites*, *Stelegmites*, *Oſteocollas*, &c.

At length, when theſe concretic juices iſſue immediately from a very hard matter, as from marble and hard ſtone, the lapidific matter conveyed by the water, being as homogenous as it poſſibly can be, and the water having as I may ſay, rather diſſolved than looſened the ſmall conſtituent parts, by uniting, it takes a conſtant and regular figure, and forms columns, terminated by a triangular point, which are tranſparent and compoſed of oblique ſtrata, this is what called *Sparr* or *Spall*. This matter is generally tranſparent and colourleſs, but it is ſometimes alſo coloured, when the hard ſtone or marble from whence it iſſues, contains metallic parts. This Spar has the degree of hardneſs of ſtone, it diſſolves, like ſtone, by acid ſpirits; it calcines with the ſame heat, therefore we cannot doubt but that it is real ſtone, become perfectly homogenous; it might even be ſaid that is pure

pure and elementary ſtone, under its proper and ſpecific form.

Notwithſtanding moſt naturaliſts look on this matter as a direct ſubſtance, exiſting independent of the ſtone, that is their lapidific or chryſtalline juice; which according to them, not only binds the parts of the ſtone common, but even thoſe of flint; this juice, ſay they, augments the denſity of ſtone by reiterated infiltrations, it renders them every day more ſtony than they were, and at length convert them in real flint; and when this juice is fixed in ſpar, it receives by reiterated infiltration ſimilar juices, ſtill further depurated, which increaſes its denſity and hardneſs, ſo that this matter having ſucceſſively become ſpar, glaſs, and then chryſtal, becomes a diamond. Thus all ſtones, according to them, and all tranſparent matters to become diamonds.

But if this is true, why do we ſee, throughout whole provinces, this chryſtalline juice form only ſtone, and that in other provinces, it forms only flint? Will they ſay, that the two ſoils are not of a like age, that this juice has not had time to circulate and act as long in one as the other? This is not probable, beſides, from whence does this juice proceed? If it produces ſtone and flints, what is it that produces this juice? It is plainly apparent that it does not exiſt independent of theſe matters, which of themſelves can give to the water which penetrates them, this petrifying quality, always relative to their native and ſpecific character; inſomuch that in ſtones it forms ſpar, and in flints chryſtal, and there are as many different kinds of this juice, as there are different matters which produce them, and from which they proceed. Experience perfectly agrees with what we relate; we ſhall always find that the water which runs in gutters in ſtone quarries, generally form ſoft and calcin-

cinable ſtones, as the ſeſtones are; that on the contrary, thoſe which ſpring from rock and flint, form hard and vitrfiable congelations, which have all the other properties of flint, as the firſt have all thoſe of ſtone, and the waters which have penetrated the beds of mineral and metallic matters, afford room for the production of pyrites, marcaſites, and grains.

We have obſerved, that we might divide all matters into two great claſſes, and two general characters; ſome vitrifiable and others calcinable; argilaceous earth and flint; marle and ſtone may be looked upon as the two extremes of each of theſe claſſes, the intervals of which are filled with the almoſt infinite variety of the mixt matters which have always one or the other of theſe matters for their baſe.

The matters of the firſt claſs can never acquire the nature and properties of that of the other; the ſtone it may be ſuppoſed, will always be as remote from the nature of flint, as potters earth is from marle; no known agent will be even capable of making them quit the circle of combinations proper for their nature: the country where there is only marble and ſtone, as certainly as thoſe wherein there is only gre's, flint and rock, will never be ſtone or marble.

If we obſerve the order and diſtribution of matters in a hill compoſed of vitrifiable matters, as we have done in a hill compoſed of calcinable matters, we ſhall commonly find under the firſt bed of vegetable earth, a bed of clay or potters earth, a vitrifiable matter, analogous to flint, and which as I have obſerved is only decompoſed vitrifiable ſand: this bed of argilaceous earth or ſand anſwers to a bed of gravel which is met with in hills compoſed of calcinable matters; after this ſtrata of argilaceous

ous earth and ſand, we meet with ſome beds of gres, which moſt often are no more than ſix inches thick and divided into ſmall pieces by an infinity of perpendicular clefts, like the rough pieces of the third bed of the hill compoſed of calcinable matters. Under this bed of gres, we meet with many others of the ſame matter, and alſo beds of vitrifiable and the gres becomes harder and is found in ſome beds in larger blocks in proportion as we deſcend ; underneath theſe beds of gres we meet with a very hard matter which I have called *live rock* or *flint in large maſſes*, it is a very hard denſe matter, which reſiſts the file, graver and acid ſpirits much more than vitrifiable ſand, and even powdered glaſs on which aqua-fortis ſeems to have ſome effect. This matter ſtruck by another hard body emits ſparks, and exhales a very penetrating ſmell of ſulphur. This matter, I have thought proper to call *maſſy flint*, is generally *ſtratified*, or other beds of potters earth, coals, vitrifiable ſand, &c. of a very great thickneſs : and theſe beds of flint anſwer to the ſtrata of hard matter and marbles, which ſerve as a baſe to hills compoſed of calcinable matters.

Water by flowing through perpendicular clefts, and by penetrating the ſtrata of theſe vitrifiable ſands, gres, argilaceous earth, loads itſelf with the fineſt and moſt homogenous parts of theſe matters, and forms many different connections, ſuch as talcs, amianthus's, and many other productions of theſe ſtillations of vitrifiable matters, as we ſhall explain in our diſcourſe on minerals.

Flint, notwithſtanding its extreme hardneſs and great denſity, has alſo, like common marble and like hard ſtone, its exudations, from whence ſtalactites of different kinds reſult, whoſe varieties of tranſparency, colours and configuration, are relative to the different nature of the flint which produce them

and participate alſo of the different metallic or heterrogenous matters which it contains; rock chryſtal, all precious, white or coloured ſtones and even diamond, may be regarded as ſtalactites of this kind. Flints in ſmall pieces, whoſe ſtrata are generally concentric, are alſo ſtalactites, and paraſite flinty ſtone in large pieces and moſt fine opaque ſtones are only kinds of flint; matters of a vitrifiable kind, produce, as we obſerved, as great variety of concretions as thoſe of the calcinable claſs, and theſe concretions produced by flints, are almoſt all hard and precious ſtones; whereas thoſe of the calcinable ſtone are only ſoft matters of no value.

Perpendicular clefts are found in the rocks and beds of flint in a large maſs, as well as in beds of marble and hard ſtone, they are ſometimes even larger there, which proves that this matter aſſuming a body, is ſtill dryer than ſtone: but theſe hills, the ſtrata of which we have taken notice of, of calcinable and vitrifiable matters are ſupported by clay or vitrifiable ſand, which are the common and general matters of which the globe is compoſed, and which I look on as the lighteſt parts, like the ſcoria of vitrified matter which it is internally filled with, thus all mountains or plains have argilaceous earth or ſand for their commou ſand. For example, we ſee pits at Amſterdam and Marly de Ville, which are always found at the bottom of vitrifiable ſand, I have related other examples thereon in my diſcourſe on minerals.

In moſt naked rocks it is obſervable, that the ſides of the perpendicular clefts, correſpond as exactly as thoſe of a piece of ſlit wood, and this correſpondence is found as well in narrow clefts as in the broad. In large quarries in Arabia, which are almoſt always compoſed of granite, theſe clefts or perpendicular ſeparations, are very ſenſible and frequent, and

and although there are some which ar twenty or thirty ells wide, nevertheless the ridges exactly correspond and leave a deep cavity between them. See Shaw's Travels, vol. II. p. 83. It is very common to find in perpendicular clefts shells broken in half, in a manner that each piece remains fastened to the stone on each side of the cleft; which shews that these clefts were placed in the solid part of the horizontal stratum, when it was whole, and before the cleft was made. See Woodward, p. 298.

There are certain matters in which the perpendicular clefts are very wide, as in the quarries quoted by Shaw; which, perhaps is the reason that they are not so frequently met with in the quarries of rock and granite, the stone may be cut out in large pieces; we know of some, as the great obelisks and pillars seen at Rome in divers parts, which are upwards of sixty, eighty, an hundred or one hundred feet long; these enormous blocks are all of one continued piece. It appears that these masses of granite have been worked in the quarry, and that any desired thickness had been given to them, nearly as we see that in the quarries of gres or free stone, which are somewhat deep: blocks of any size are to be cut out. There are often other matters where these perpendicular strata are very narrow; for example, in clay, marle, and chalk; they are on the contrary, wider in marble and most hard stones. There are some which are imperceptible and filled with a matter nearly similar to that of the mass in which they are found, and which nevertheless break off the continuity of the stone; this is what workmen call parts or hairs, when a great piece of stone is hewn and reduced to a slight size, as half a foot, the stone breaks in the direction of this matter. In marble, I have remarked often, that in marble and stone, that the hairs cross the block

blocks entirely, ſo that they differ from particular ſtrata, only becauſe there is no total ſolution of continuity : theſe kind of clefts are filled with a tranſparent matter, which is no other than true ſpar. There is great number of conſiderable clefts between the different rocks which compoſe quarries of gres, this proceeds from theſe rocks often reſting on leſs ſolid baſes than marble or calcinable ſtones, which generally reſt on clay; whereas gres are very often only ſupported by extremely fine ſand. There are alſo many places where gres in large pieces are met with : and in moſt quarries where good gres is hewn, we may remark that it is in cubes and parallelepipedes placed on each other in a very irregular manner, as in the hills of Fontainbleau, which at a diſtance appear to be the ruins of buildings. This irregular diſpoſition proceeds from the baſe of theſe hills being compoſed of ſand, and that theſe maſſes of gres are moved, overthrown and ſunk one on the other, particularly in places that formerly have been worked for the hewing of gres, which has formed a great number of clefts and intervals between the blocks ; and if we would pay attention thereto, we may obſerve in every part compoſed of ſand and gres, that there are pieces of rock and large ſtones in the middle of vallies and plains in very great quantity; whereas in a country of marble and hard ſtone, theſe ſcattered pieces which have rolled from the top of hills and mountains, are very ſcarce, which proceeds only from the different ſolidity of the baſe on which theſe ſtones reſt and from the extent of the banks of marble and calcinable ſtone, which is more conſiderable than that of gres.

ARTICLE XVIII.

Of the Effect of Rain, Bogs, ſubterraneous Wood, Water, &c.

WE have already obſerved, that the rain and the running waters they produce, continually detach from the tops of mountains, ſand, earth, gravel, &c. which they carry with them into plains, from whence the rivers and floods convey a part of them into lower plains and often as far as the ſea. Plains therefore are ſucceſſively filled and by degrees raiſed higher, while mountains daily diminiſh, and continually grow lower, and this ſinking is perceptible in many places. Joſeph Blancanus relates circumſtances on this ſubject, which were of public notoriety in his time, and which proves that mountains have been lowered ſo much that villages and caſtles are to be ſeen in many places where there were none formerly. In the County of Derby in England, the ſteeple of the village *Craih*, was not viſible in 1572, from a certain mountain, on account of the height of another mountain which intervened, and which extended into Hopton and Wirkworth and about eighty or an hundred years after this ſteeple and even part of the church became viſible. Doctor Plot gives us a ſimilar example of a mountain between Sibbertoft and Aſhby in Northamptonſhire. The water not only carried with it the lighteſt part of the mountains, as earth, gravel and ſmall ſtones, but they even rolled down large rocks, which conſiderably diminiſhed the height of them. The mountains of Wales are very ſteep and high, and the chip-

ings

pings (if we may be allowed that term) of theſe rocks are to be ſeen in large pieces at their feet. It is the froſt and the water which divides and carries them off. It is not alone theſe mountains of ſand and earth which the rain cauſes to ſink, as has been obſerved, they attack the hardeſt rocks, and carry with them fragments into the vallies. It happened in the valley of Nantphrancon in 1685, that a part of a large rock, which reſted only on a narrow baſe, having been undermined by the waters, fell, and broke in many pieces with more than a million of other ſtones, the largeſt of which in deſcending tore up a conſiderable trench as far as the plain, where it continued to make its way into a ſmall meadow and croſſed a ſmall river, where it ſtopped. It is to accidents ſimilar to theſe that we muſt attribute the origin of all the large ſtones found here and there adjacent to the mountains. We muſt recollect, on this obſervation, what we have before obſerved in the preceding article, viz. that theſe rocks and large ſtones ſcattered abroad, are much more common in countries whoſe mountains are compoſed of ſand and gres, than in thoſe where their compoſition is marble and clay, becauſe the ſand which ſerves as a baſe to the rock, is a leſs ſolid foundation than clay.

To give an idea of the quantity of earth which the rain detaches from the mountains and carries along with it into the vallies; we can quote a circumſtance related by Dr. Plot: he ſays, in his natural hiſtory of Staffordſhire, that eighteen feet deep in the earth, a great number of pieces of money, coined in the reign of Edward V. has been found i. e. two hundred years before his time, ſo that this ground, which is boggy, has increaſed above a foot in eleven years, or an inch and a twelfth every year. We can ſtill make a ſimilar obſervation on trees buried at

at ſeventeen feet depth, below which medals of Julius Cæſar has been found; ſo the earth brought from the top of mountains into plains by running waters, ceaſe not from very conſiderably increaſing the elevation of the ground of plains.

This gravel, ſand, and earth which the waters detaches from mountains and carries with them into plains, form ſtrata there, which muſt not be confounded with the antient and original ſtrata of the earth. In the claſs of theſe new ſtrata muſt be placed, thoſe of ſoft ſtone, gravel and ſand, the grains of which are waſhed and rounded; to this claſs muſt alſo be referred the ſtrata of ſtones which are formed by a kind of depoſit and incruſtation; all theſe ſtrata do not owe their origin to the motion and ſediments of the ſea. In theſe gravelly and ſoft and imperfect ſtones are found an infinity of vegetable leaves, terreſtrial and fluviatile ſhells, ſmall bones of terreſtrial animals, but never ſea ſhells or other marine productions; which evidently proves as well as their ſlight ſolidity, that theſe ſtrata are formed on the ſurface of the dry land, and that they are much more modern than the marble and other ſtones which contain ſhells and which were formerly formed in the ſea. Gravel and all theſe modern ſtones appear to be hard and ſolid when they are hewn out, but when they are worked, we find that the air and rain preſently diſſolve them: their ſubſtance is even ſo different from true ſtone, that when they are reduced into minute parts, and ſand attempted to be made from them, they preſently are converted into a kind of earth or clay. Statactites and other ſtony concretions, which Tournefort takes for vegetated marble, are not real ſtones, no more than thoſe formed by incruſtations. We have already ſhewn that gravel is not of ancient formation and that

that it muſt not be ranked among the claſs of ſtones. Turf is an imperfect matter, which derives its origin from both by the means of rain water, as the ſtrong incruſtations derive theirs from the depoſit of the water of certain ſprings; therefore the ſtrata of theſe matters are not ancient and have not been formed like the reſt, by the ſediment of the ſea. The ſtrata of turf muſt be likewiſe regarded as modern ſtrata which have been produced by the ſucceſſive aſſemblage of leaves and other periſhable vegetables, and which are only preſerved by falling into bituminous earth, which has prevented them from being entirely corrupted. Among theſe modern ſtrata of gravel, we never meet with, either ſoft ſtone or ſtone formed by the depoſit, either of turf or any marine production; but, on the contrary, we meet with many vegetables, bones of land animals, fluviatile and terreſtrial ſhells, as may be ſeen in the meadows of the county of Northampton near Aſhby, where a great number of ſnail ſhells, with plants, herbs and many fluviatile ſhells, are found, all in good preſervation, ſome feet deep in the earth, but never any marine ſhells. See Philoſoph. Tranſ. Abridg. II. p. 271.

The water which runs on the ſurface of the earth, have formed all theſe new ſtrata, by often changing ſituation and diſperſing themſelves on every ſide: a part of theſe waters penetrate internally and flow acroſs the clefts of rocks and ſtone; and the reaſon we meet with no water in high lands, no more than on the tops of hills, is becauſe, all elevations of land are generally compoſed of ſtone and rocks, eſpecially towards the ſummit, to find water, we dig into the ſtone and rock till we come to the baſe, i. e. to the clay or firm earth on which theſe rocks reſt, and we ſhall not

not meet with any water untill the thickneſs of the ſtone is pierced to the bottom, as I have obſerved in many pit dug in high places, and when the height of rocks, i. e. the thickneſs of the ſtone, which muſt be pierced, is very conſiderable, as in lofty mountains, where the rocks are upwards of an hundred feet in height, it is impoſſible to dig pits or wells or to have any water. There are even large parts of land and water abſolutely deficient; as in Arabia Petrea, which is a deſert where no rain ever falls, where the ſcorching ſand covers the whole land, where there is no vegetable earth, where the few plants found there, languiſh, and where ſprings and wells are ſo very ſcarce, that only five is reckoned between Cairo to mount Sina, and the water is brackiſh.

When the waters on the ſurface of the earth, cannot find vent to flow, they form moraſſes and bogs; the moſt famous moraſſes in Europe, are thoſe of Muſcovy at the ſource of Tanais, thoſe of Finland, where the great moraſſes of Savolax and Enaſak are; there are alſo ſome in Holland, Weſtphalia, and many other low countries; in Aſia, the moraſſes of the Euphratus, thoſe of Tartary, and the Palus Meotidis: nevertheleſs, in general there are fewer of them in Aſia and Africa than in Europe; but America may be ſaid to be but one continued moraſs, throughout all its plains; this great number of moraſſes is a proof of the modern date of the country, and of the ſmall number of inhabitants, and ſtill more of their want of induſtry.

There are very great bogs in England near the ſea in Lincolnſhire, which has loſt much ground on one ſide, and gained it on the other. In the ancient ground a great quantity of trees are found which are buried there below the modern ground by the water; the ſame likewiſe are met with in Scot-

Scotland, at the mouth of the river Nefs. Near Bruges in Flanders, by digging to the depth of 40 or 50 feet, we find a great quantity of trees as clofe to each other as in a foreft, the trunks, branches, and leaves are fo well preferved that the different kinds are eafily diftinguifhable; 500 years are paffed fince this land where the trees are found was covered by the fea, and before this time, there is no trace of memory or tradition that this land ever exifted; neverthelefs, it is neceffary, for this formerly to have been fo, when thefe trees ftood and vegetated, therefore the ground which formerly was covered with wood, has afterwards been fubmerged by the fea, which has brought thither 40 or 50 feet thicknefs of earth, which water has afterwards retired and left the earth behind. A great number of fubterraneous trees has been alfo found at Youle in Yorkfhire, twelve miles below the town, in the river Humber, there are fome large enough for building; and it faid, perhaps improperly, that this wood is as durable and as ferviceable as oak, it is cut into fmall fticks and chips, which are fold in the neighbouring towns for pipe lights. All thefe trees appear broken, and the trunks are feperated from the roots, like trees which the violence of an hurricane, or an inundation has broken and carried away: this wood greatly refembles willow, it has the fame fmell when burnt, and makes charcoal exactly like it. See Philofophical Tranfactions. No. 228. In the ifle of Man, there is a morafs fix miles long by three broad, it is called Curragh, fubterraneous trees like willows are found there, and although they are 18 or 20 feet high, they are neverthelefs firm on their roots. See Ray's Difcourfes page 232. Trees are met with almoft in every morafs, in bogs, and in moft

marfhy

marſhy places; in the counties of Somerſet, Cheſter, Lancaſter, and Stafford, there are ſome places where trees are found under the earth, which have been cut, ſawed, ſquared, and worked by the labour of man; wedges and ſaws have likewiſe been found, and betwixt Birmingham and Brumley in the county of Lincolnſhire, there are lofty hills of fine light ſand, which the rain and wind ſweep away, leaving uncovered the roots of large willow trees, where the impreſſion of the ax appears to be as freſh as if juſt done. Theſe hills without doubt are formed like downs, by the maſs of ſand which the ſea has brought thither, accumulated together, and on which theſe willows might have grown; they have afterwards been again covered by other ſands, which have been brought thither like the firſt, by an inundation or violent winds. A great number of theſe ſubterraneous trees are alſo found in the marſhy lands of Holland, Frieſland, and near Groningen, from whence the turfs which they burn are dug.

In the earth are found an infinite number of large and ſmall trees of every kind, as willows, oaks, firs, aſpins, &c. in the moraſs of Lincoln, along the river Ouſe, and in the county of York, in Hatfield Chace, theſe trees are ſtrait and planted as we ſee them in a foreſt. The oaks are very hard and uſed in buildings, where they laſt a long time (*a*) the aſh are tender and crumble to duſt, as well as the willows: ſome are found which have been curved and faſhioned, others bored with broken

(*a*) I muſt doubt the authenticity of this circumſtance, all trees that are dug out of the earth, at leaſt, all thoſe which I have ſeen, whether oak, or others, loſe in drying all all the ſolidity which they appeared to have at firſt and ought never to be uſed in buildings.

wedges

wedges found therein, and hatchets whose forms resembled the knives used in sacrifices, nuts, almonds, &c. in great quantities. Many other fenny parts of England and Ireland are filled with trunks of trees, as well as the morasses of France, Sweden, Savoy, and Italy. See Transactions Philosophical Abridg. Vol. IV. page 218, &c.

In the city of Modena and four miles round, whatever part is dug, when we reach the depth of sixty-three feet, and bored five feet deeper with an auger, the water springs out with such great force, that the well is filled in a very short space of time, this water flows continually, and neither diminishes nor increases by the rain or drought: what is remarkable in this ground, is, that when we reach the depth of fourteen feet, we find pavements, and other ruins of an ancient town, as boards, houses, different pieces of mosaic work, &c. after which we find a very solid ground, which is thought to have never been stirred, yet below it we find a moist earth mixed with vegetables, and at twenty-six feet are entire trees, as nut-trees with nuts thereon, and a great quantity of branches and leaves of trees; at twenty-eight feet depth we meet with a friable chalk mixed with many shells, and this bed is eleven feet in thickness, after which we again meet with vegetables; and so on alternatively chalk and earth mixed with vegetables, to the depth of sixty-three feet, at which depth is a bed of sand mixed with some gravel and shells, like those formed on the coasts of the Italian sea; these successive beds of fenny or marshy earth and chalk, are always met with in the same order, wheresoever we dig, and very often the auger meets with large trunks of trees, which it bores through, and which occasions great trouble to the workmen: bones, coals, flint, and pieces of iron are also found. Ramazzini,

who relates theſe circumſtances, thinks that the gulph of Venice formerly extended as far even beyond Modena, and that by courſe of time, and perhaps by the inundations of the ſea, this ground has been formed.

I ſhall no longer dwell on the varieties which theſe ſtrata of modern formation preſent, it ſuffices to have ſhewn that they have no other canſes than the current and ſtagnant waters, which are at the ſurface of the earth, and that they are never ſo hard nor ſolid as the ancient ſtrata which are found under the waters of the ſea.

ARTICLE XIX.

Of the mutations of Land into Sea and Sea into Land.

BY what has been ſaid in the articles i, vii, viii,and ix, it appears that great mutations have happened to the terreſtrial globe, which may be looked upon as general; and it is certain by what we have related in other articles, that the ſurface of the earth has undergone particular alterations, although the order or rather the ſucceſſion, of theſe particular alterations or changings are not perfectly known to us, however, we are acquainted with the principal cauſes, and are even in a ſtate of diſtinguiſhing their different effects; and if we could collect all the circumſtances which Natural and Civil Hiſtory furniſh us with on the ſubject of the revolutions which have happened to the ſurface of the earth, we do not doubt but that the theory of the earth which we have laid down would become much more plauſible.

One of the principal cauſes of the alteration which are happened on the earth, is the motion of the ſea, a motion it has endured from the earlieſt ages of the world; for ſince the creation there has been the ſun, land, water, air, &c. hence the flux and reflux, the motion from eaſt to weſt, and the motion of the winds and currents are felt; the waters ſince then have had the ſame motions as we at preſent remark in the ſea; and if even we ſhould ſuppoſe that the motion of the globe has had another inclination, and that the terreſtrial continents,

hents as well as the ſea, has had another diſpoſition, it does not deſtroy the motion of flux and reflux, no more than the cauſe and effects of the winds: it is ſufficient that the immenſe quantity of water, which fills the vaſt ſpace of the ſea, is found in ſome part on the globe of the earth, and that the flux and reflux and other motions of the ſea have been produced.

When we have once began to ſuppoſe that formerly our continent was the bottom of a ſea, we ſhall ſoon have no doubt remaining thereon; on one ſide, thoſe devaſtations of the ſea, which is every where to be met with; on the other, the horizontal ſituation of the ſtrata of the earth; and laſtly, that diſpoſition of hills and mountains which correſpond with each other, appear as ſo many convincing proofs thereof: for by conſidering the plains, vallies, and hills, we clearly perceive that the ſurface of the earth has been formed by the waters; by examining the internal parts of ſhells which are incloſed in ſtones, we evidently diſcover that theſe ſtones are formed by the ſediments of the waters, ſince ſhells are found filled with the ſame matter as the ſtones which ſurround them, and laſtly, by reflecting on the form of hills whoſe ſaillant angles always correſpond to the returning angles of oppoſite hills, we cannot doubt but that this direction is the work of the currents of the ſea; in fact, ſince our continent has been diſcovered, the form has been ſomewhat changed, the mountains have diminiſhed in height, the plains are grown higher, the angles of hills become more obtuſe, many matters waſhed away by floods or rivers have taken a round ſhape, beds of gravel, ſoft ſtone, &c. have been formed; but the eſſential matter is ſtill remaining, the ancient form is ſtill apparent, and I am perſuaded that all the world may be convinced by their

their own inſpection of what we have advanced on this ſubject; and whoſoever follows our obſervations and proofs, will not doubt but that the earth was formerly covered by the waters of the ſea, and that it is the currents of the ſea which has given to the ſurface of the earth, the form we at preſent ſee it in.

The principal motion of the waters of the ſea, is, as we have ſaid, from eaſt to weſt; it alſo appears to us that the ſea has gained above 500 leagues of ground on the eaſtern ſide, as well of the old as the new continent: we muſt recollect the proofs we have given in the eleventh article, and we may add thereto, that all the ſtraits which join the ſe, are directed from eaſt to weſt, the ſtrait of Magellan, the two ſtraits of Forbiſher's, that of Hudſon, the ſtrait of the iſland of Ceylon, thoſe of the ſea of Corea and Kamtſchatka have all this direction, and appear to have been formed by the direction of the waters, which being impelled from eaſt to weſt, opened theſe paſſages in the ſame direction, and in which they undergo alſo a more conſiderable motion than in all the other directions; for in theſe ſtraits there are very violent tides, whereas in thoſe which are ſituated on the weſtern coaſts, like that of Gibralter, Sund, &c. the motion of the tides is almoſt inſenſible.

The inequalities of the bottom of the ſea change the direction of the waters motion, and have been ſucceſſively produced by the ſediment of the water, and by the matters which they have tranſported, either by its motion of flux and reflux, or by other motions; for we do not aſcribe the motion of flux and reflux for the ſole cauſe of thoſe inequalities, we have only given this cauſe as the principal and firſt, becauſe it is the moſt conſtant and acts without interruption; but we muſt alſo admit the action of

of the winds as a cause, they even act at the surface of the water with quite another violence than the tides, and the agitations which they communicate to the sea is much more considerable for the external effects, it extends even to considerable depths, as we see by the matters, which are loosened, by a storm, from the bottom of the sea, and which are almost never thrown on shores but in tempestuous weather.

We have already mentioned that between the tropics, and even some degrees beyond them, an east wind continually blows; this wind which contributes to the general motion of the sea from east to west, is as ancient as the flux and reflux, since it depends on the course of the sun, and the rarefaction of the air, produced by the heat of this planet. Here then are two united causes of motion, which are greater under the equator than elsewhere. The first, the flux and reflux, which as is well known, is more sensibly felt in southern climates: and the second, the east wind which blows, continually in the same climates: these two causes have concurred ever since the formation of the globe to produce the same effects, that is say, to cause the waters to move from east to west, and to agitate them more in that part of the world than in all the rest; it is for this reason that the greatest inequalities of the surface of the globe are found between the tropics. The part of Africa comprehended between these two circles, is, as I may say, only a group of mountains whose different chains extend for the most part from east to west, as we may be assured of by considering the direction of the greatest rivers of this part of Africa; it is the same with the part of Asia and that of America which are comprised between the tropics and we must judge of the inequality and surface of these climates by the

quantity

quantity of high mountains and iſlands met with in that part of the globe.

From the combination of the general motion of the ſea from eaſt to weſt, of that of the flux and reflux, of that produced by the currents, and likewiſe that which forms the winds, an infinite number of different effects has reſulted, as well on the bottom of the ſea, as on the coaſts and continents. Varenius ſays, that it is very probable that the gulphs and ſtraits have been formed by the reiterated effort of the ocean againſt the land : that the Mediterranean ſea, the gulphs of Arabia, Bengal, and Cambay have been formed by the irruption of the waters, as well as the ſtraits between Sicily and Italy, between Ceylon and the Indus, between Greece and Eubea, and that it is the ſame with reſpect to the ſtrait of the Manillas, that of Magellan, and that of Denmark ; that one proof of the irruption of the oceans on the continents, that one proof that it has forſaken different countries, is, that but few iſlands are to be met with in the great ſeas, and never a great number of iſlands cloſe to each other; that in the immenſe ſpace occupied by the Pacific ſea, not above two or three ſmall iſlands are to be found towards the middle of it ; that in the vaſt Atlantic ocean between Africa and the Brazils, we only find the ſmall iſlands of St. Helena and Aſcenſion ; but that all iſlands are near the great continents, as the iſlands of the Archipelago near the continents of Europe and Aſia, the Canaries near Africa, all the iſlands of the Indian ſea near the Oriental coaſt, the Antille iſlands near that of America, and that there are only the Acoras which have any great projection into the ſea between Europe and America.

The inhabitants of Ceylon ſay, that their iſland was almoſt ſeperated from the peninſula of the Indus by an irruption of the ocean, and this popular tradition

dition is very probable; it is alſo imagined that the iſland Sumatra has been ſeperated from Malayo, the great number of ſhoals and ſand banks are a ſtrong proof of it. The Malabars aſſure us, that the Maldivian iſlands formed a part of the continent and in general it may be reaſonably ſuppoſed that all the eaſtern iſlands have been divided from the continents by an irruption of the ocean. See Varenius Geography, page 203, 217, and 220.

There is an appearance that formerly the iſland of Great Britain formed a part of the continent, and that England was joined to France; the beds of earth and ſtone, which are alike on both ſide of the paſſage between Calais and Dover, and the little depth of this ſtrait ſeem to indicate it: by ſuppoſing, ſays Dr. Wallis, "as every thing appears to indicate, that England formerly communicated with France by an iſthmus below Dover and Calais; the ſeas drove againſt the coaſts of this iſthmus by an impetuous flux twice in twenty-four hours, the German ocean, which is between England and Holland, ſtruck this iſthmus on the eaſtern ſide and that of France on the weſt, is ſufficient in time to wear away and deſtroy a neck of narrow land, ſuch as we ſuppoſe this iſthmus formerly to have been; the flux of the ſea of France acting with great violence, not only againſt, but alſo againſt the coaſts of France and England, muſt conſequently by the motion of the waters, have waſhed away a great quantity of ſand, earth, and mud, from every part againſt which the ſea ſtruck: but, being ſtopt in its courſe by this iſthmus, it muſt not have depoſited, as might be ſuppoſed, ſediments againſt the iſthmus, but tranſported them into the great plain which actually forms Romney marſh, which is fourteen miles long by eight broad; for whoſoever has ſeen this plain, cannot doubt but that it

The German ſea muſt have acted in the ſame manner againſt the iſthmus, and the coaſts of England and Flanders, and will have conveyed away the ſediment into Holland and Zeland, the ground of which that was formerly covered with water, is riſen above forty feet; on the other ſide, on the coaſt of England, the German ſea muſt have filled up this large valley where the river Stour actually flows, for more than 20 miles, to begin at Sandwich Canterbury, Chatham, Chilham as far as Aſhford, and perhaps farther: the ground is actually much higher than it was formerly, ſince at Chatham the bones of an Hippopotamus was found ſeventeen feet deep in the earth, together with anchors and marine ſhells.

Now it is very probable the ſea may form new ground, by bringing to it ſand, earth, mud, &c. for we have ocular proof in the iſland of Orkney, which is adjacent to Romney Marſh, there was a tract of low land, which was continually in danger of being inundated by the river Rother; but in leſs than ſixty years the ground has conſiderably riſen, by a great quantity of earth and mud being brought thither at each flux and reflux, and at the ſame time it has ſo greatly hollowed the canal through which it enters, that in leſs than fifty years the depth of this canal is become big enough to admit of the reception of large veſſels, whereas before it was a ford over which people might paſs.

The ſame thing happened near the coaſt of Norfolk, and it is in this manner that the ſand is formed which extends obliquely from the coaſt of Norfolk towards the coaſt of Zeland: this bank forms that part where the tides of the German and French ſea meet, ſince the iſthmus has been broken, and where the earth and ſand are depoſited which are waſhed away from the coaſts: it is not certain

whether this ſand bank will not form a new iſthmus, &c. See Abridgement of Philoſophical Tranſactions, Vol. II. page 227.

There is a great appearance (ſays Ray) that the iſland of Great Britain was formerly joined to France, and formed part of that continent; it is not known whether it was cauſed by an earthquake, an irruption of the ocean, or by the labour of man, for the utility and convenience of paſſage, or from other cauſes; but what ſtill further proves that this iſland formed part of this continent, is, that the rocks and coaſts of both are of the ſame nature, and compoſed of the ſame matters, to the ſame height, inſomuch that along the Dover coaſts we meet with the like beds of ſtone and chalk as between Calais and Boulogne; the length of theſe rocks along theſe coaſts is nearly the ſame on each ſide, that is to ſay, about ſix miles: the little breadth of the canal, which in this part is not more than twenty-four Engliſh miles, and the ſhallowneſs of it, with reſpect to the neighbouring ſea, gives us reaſon to think that England has been divided from France, by accident; we may add to theſe proofs, that there were formerly wolves and even bears in this iſland, and it is not to be preſumed that they came there by ſwimming over, nor that men formerly tranſported theſe noxious animals; for in general we find theſe animals of the continents in all the adjacent iſlands, and never in thoſe which are ſeperated from them by a great diſtance, as the the Spaniards obſerved when they landed in America. See Ray's Diſcourſes, page 208.

In the reign of Henry I. king of England, a great inundation happened in part of Flanders: in 1446 a like irruption deſtoyed 10,000 perſons on the territory of Dordrecht, and more than 100,000 round Dullart, Friezland, and Zeland; and in theſe

these last two provinces there were upwards of 2 or 300 villages submerged, the tops of their towers, and the steeples of their churches are still to be seen rising out of the water.

On the coasts of France, England, Holland, Germany, and Prussia, the sea has retreated in many parts. Hubert Thomas relates in his description of Liege, that the sea formerly surrounded the walls of the town of Tongres, which is more than thirty-five leagues distant from it, which he proves by many eligible reasons; and among others, he says, that in his time the iron rings to which the ships that came to the place were moored were to be seen. We may likewise look on as countries deserted by the sea, the fens and bogs of Lincoln, in England; those of Provence, in France; and even the sea is very considerably retreated at the mouth of the Rhone, since the year 1665. In Italy it has likewise formed a considerable tract of ground at the mouth of the Arne and Ravenna, which was formerly a sea port of the Exarques, is no longer a maritime town; all Holland appears to be a new country, where the surface of the earth is almost on a level with the bottom of the sea, although the land is considerably risen, and is still rising every day by the mud and earth which the Rhine, Maze, &c. bring thither: for formerly it was computed that the ground of Holland was in many places, fifty feet lower than the bottom of the sea.

It is asserted that in the year 860, that a furious tempest, brought towards the coast so great a quantity of sand, that it shut up the mouth of the Rhine near the Cat, and that this river inundated the whole country, tore up trees and houses, and threw itself into the bed of the Maze. In 1421, there was another inundation which seperated the town of Dordrecht from the main land, submerged seventy-

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two villages, many caſtles, drowned 100,000 ſouls, and deſtroyed an infinite number of cattle. The dyke of Yſſel was broken in 1638, by the quantity of ice brought down by the Rhine; which having ſhut up the paſſage of the water, made an opening of ſome fathoms width in the dike and a part of the province was inundated, before the breach could be repaired. In 1682 there was a ſimilar inundation in the province of Zeland, which ſubmerged upwards of thirty villages, and cauſed the loſs of an infinite number of people and cattle which were ſurprized in the night by the waters. It was a fortunate circumſtance for Holland that the ſouth wind gained ground on that which was oppoſed to it; for the ſea was ſo greatly ſwelled that the water was eighteen feet higher than the higheſt ground of the province, excepting the downs. See the Hiſtorical Voyages of Europe, Vol. V. page 70.

At Hithe, in the county of Kent, in England, there was a port which fills in ſpite of all the precautions taken to prevent it, and in ſpite of the expence incurred to empty it; a ſurprizing number of ſhells, &c. are found, which are brought there by the ſea, in extent of ſeveral miles, which were formerly heaped together, and which in our time have been covered by the mud and earth, on which there are actually meadows. On the other ſide are iſlands which the ſea has covered, as the Goodwin Sands, which belonged to an earl of that name, and which at preſent are no more than ſand covered by the water of the ſea, thus the ſea in many places gains on the land, and loſes ground in others, which depends on the different ſituation the coaſts and places where the tides ſtop, or the waters tranſport from one place to another, earth, ſand,

ſand, ſhells, &c. See Abridgement Philoſophical Tranſactions, Vol. IV. page 234.

On the mountain of Stella, in Portugal, is a lake in which the wrecks of ſhips have been found, notwithſtanding this mountain is more than twelve leagues diſtant from any ſea. See Gordon's Geography, London edition, 1733, page 149. Sabinus in his commentaries on Ovid's Metamorphoſes, ſays, that by the monuments of hiſtory it appears, that in the year 1460 a whole ſhip with its anchors was found in a mine of the Alps.

It is not only in Europe that we meet with examples of theſe viciſſitudes of land into ſea and ſea into land; other parts of the world might furniſh us, perhaps, with more remarkable and in a greater number, if we had obſerved them with precaution.

Calicut was formerly a famous town, and the capital of a kingdom of the ſame name, at preſent it is only a large borough, meanly built, and but thinly inhabited: the ſea which ſince a century has gained greatly on this coaſt, has ſubmerged part of the old town, with a beautiful fortreſs of ſtone which was therein. Veſſels at preſent moor on their ruins, and the port is filled with a great number of ſhoals, which appear at low water, and on which ſhips very often are wrecked. See Lettres Edifiantes Recueil, II. page 187.

The province of Jucatan, a peninſula in the gulph of Mexico, was formerly a part of the ſea, this piece of ground extends 100 leagues in length from the continent into the ſea, and is no more than twenty-five leagues in its greateſt breadth: the quality of the air in that part is perfectly hot and moiſt: although there is neither rivulets nor rivers throughout ſo long a ſpace, the water is every where ſo nigh the ſurface that by opening the earth, ſo great a number of ſhells are found, that this vaſt ex-

extent may be regarded as a place which formerly formed part of the ſea.

The inhabitants of Malabar pretend, that formerly the Maldivian iſlands were attached to the Indian continent, and that the violence of the ſea has divided them, the number of theſe iſlands is ſo great, and ſome of the canals which ſeperate them are ſo narrow, that the boltſprits of the veſſels which paſs through them, tear of the leaves of the trees on each ſide, and in ſome places an active man by holding by the branch of a tree may leap into another iſland. See the Dutch Travels to the Eaſt Indies, page 274.

A proof that the continent of Maldivia was formerly dry land, are the cocoa trees which are at the bottom of the ſea, cocoa nuts often being detached from them and thrown on the ſhore by a ſtorm: the Indians ſet great ſtore by them, and attribute the ſame virtues to them as to the bezoar.

It is imagined that this iſland of Ceylon was formerly united to the continent and formed a part thereof; but, that the currents which are extremely rapid in many parts of India, have divided and formed an iſland. The ſame ſuppoſition is made with reſpect to Rammanokiel and many other iſlands. See the Dutch Travels to the Eaſt Indies, vol. II. p. 485. However, it is certain, that the iſland of Ceylon has loſt thirty or forty leagues of ground towards the northweſt ſide which the ſea has ſucceſſively gained.

It appears that the ſea has within a ſhort time forſaken a great part of the projecting lands and American iſlands: we have juſt obſerved that the ground of Jucatan is compoſed only of ſhells, it is the ſame with the low lands of Martinico and the other Antille iſlands. The inhabitants have term-

termed the bottom of their ground LIME, becaufe they make their lime with thefe fhells, banks of which are found immediately under the vegetable earth. We may here relate what is faid in the new voyages to the iflands of America: "Lime which "is found throughout the large land of Guada-"loupe, when the earth is turned up, is of the "fame kind as that which is drawn out of the "fea, the reafon of which is difficult to be affign-"ed. Might it not be poffible that all the extent "of ground which compofes this ifland, was in "former times only a high ground filled with lime "plants, which having formerly grew and filled "the void fpaces which were occupied by the "water, betwixt them have at length raifed up "the ground and obliged the water to retire and "leave all the fuperficies dry? This conjecture, "as extraordinary as at firft it may appear, has "neverthelefs nothing impoffible in it and will "even become very probable to thofe who will "examine it without prejudice; for, in fhort, by "purfuing the commencement of my fuppofition, "plants having grown and filled all the fpaces "which the water occupied, at length fuffocated "each other: the upper parts were reduced to "powder and earth, birds dropt thereon the feeds "of fome trees, which germinated and produced "thofe which are now to be feen there, and na-"ture germinated others which are not of a com-"mon fpecies to other places, as the marble and "violet woods. It would not be unworthy the "curiofity of people who refide there, to dig in "feveral parts of the earth in that country to know "what the real foil is, and to what depth this lime "ftone is to be found, in what fituation it is diffufed "under the earth, and other circumftances which "might deftroy or ftrengthen my conjecture."

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There are ſome lands which are ſometimes covered with water, and ſometimes uncovered, as many iſlands in Norway, Scotland, Maldivia, the gulph of Cambay, &c. The Baltic has by little and little gained a great part of Pomerania, and covered and deſtroyed the famous port of Vineta; ſo likewiſe the ſea of Norway has formed many ſmall iſlands and projected into the continent: the German ſea has projected into Holland near Catwyck, inſomuch that the ruins of an ancient town of the Romans which was formerly on the coaſt, are actually very far in the ſea. The marſhy grounds in the iſle of Ely in England, are on the contrary, as we have obſerved, land which the ſea has abandoned. Downs have been formed by the ſea winds, which have thrown and accumulated earth, ſand, ſhells, &c. on the ſhore. For example, on the weſtern coaſt of France, Spain and Africa, durable and violent weſterly winds reign, which impel the waters towards the ſhore with great impetuoſity, on which downs are formed in ſome places. So likewiſe the eaſterly winds, when they remain any long time, ſo ſtrongly drive the waters from the coaſts of Syria and Phenicia, that the chain of rocks which are covered with the water during the weſterly wind, then remain dry: in the whole downs are never compoſed of ſtone or marble, like mountains formed in the bottom of the ſea: becauſe, they have not been long enough under the water. In our diſcourſe on minerals we have ſhewn, that petrification operates at the bottom of the ſea, and that the ſtones formed in the earth, are quite different from thoſe formed in the ſea.

As I was putting my finiſhing ſtroke to this Eſſay on the Theory of the Earth, which I compoſed in 1744, I received from Monſieur Barrere, his diſſertation on the origin of figured ſtones, and I was

was charmed to find myself of the same opinion with this able naturalist, on the subject of the formation of downs and the time which the water remained on the earth which we inhabit: he recounts many alterations which have happened to the sea coasts. *Aigues mortes*, which is actually more than a league and a half from the sea, was formerly a part of it in the time of Saint Louis: Psalmodi was an island in 815, and at present it is inland two leagues from the sea. It is the same with respect to Maguellona. The greatest part of the vineyard of Agde, was forty years ago covered by the sea: and in Spain, the sea has considerably retreated within a short space of time from the mouth of the river Vobregat, towards Cape Tortosa along the coasts of Valentia, &c.

The sea can form hills and raise mountains, in many different manners; at first, by the transportations of earth, mud and shells from one place to another, either by its natural motion of flux or reflux, or by the agitation of the water caused by the wind: in the second place, by sediment and impalpable parts which it will have detached from the coasts and bottom, and which it might have transported and deposited at a considerable distance, and lastly, by the shells, mud and earth which the sea winds often drive against coasts, producing downs and hills, which the water by degrees forsake, and become parts of the continent. We have an example in our downs in Flanders and in those of Holland, which are only hills composed of sand and shells, which the sea winds have driven towards the land. Monsieur Barrere quotes another example, which appears to me to merit a place in this work. "The sea by its motion, detaches from its bosom "an infinity of plants, shells, mud, and sand, "which the waves continually drive towards the "shore,

" ſhore, and which the impetuous ſea winds further
" aſſiſt to impel. Now all theſe different ſtrokes
" added to the firſt continual increaſe of ground
" occaſioned by the driving of the ſoil, &c. againſt
" the coaſts, form there many new ſtrata or heaps,
" which can only ſerve to increaſe the bed of earth,
" to raiſe it and form downs, and hills by the
" ſand and earth heaped up, &c. In one word, to
" remove to a greater diſtance the baſon of the ſea
" and form a new continent."

It is viſible that the alluvions and ſucceſſive aterisments have been formed by the ſame mechaniſm for many centuries, that is to ſay, by the reiterated depoſitions of different matters, I find proofs thereof in nature herſelf; that is to ſay, in the different beds of foſſils, ſhells and other marine productions, I obſerved in Rouſſillon near the village of Naffrac, about ſeven or eight leagues diſtance from the ſea, theſe beds of ſhells which are inclined from the weſt to the eaſt, and in different angles, are ſeparated from each other by banks of ſand and earth, ſometimes from two to three feet in thickneſs; they appear as if ſprinkled with ſalt in dry weather, and form together hillocks from twenty-five to thirty fathom in height; now a long chain of hills, can only be formed long-ways at different ſucceſſions of time, which alſo might be the effect of the deluge, which muſt have diſturbed all nature; but, which nevertheleſs have not given a regular form to theſe different beds of foſſil ſhells, which muſt have been collected together without any order or regularity."

On this ſubject I am of the ſame opinion as M. Barrere, only I do not ſpeak of the aterisments as the only mode in which mountains have been formed, and I imagine it may, on the contrary be aſſerted, that moſt of the eminences ſeen on the ſur-

ſurface of the earth, have been formed in the ſea itſelf, and that for many reaſons which have appeared to me to be convincive : firſt, becauſe that between them there is that correſpondence of ſaillant and returning angles, which neceſſarily ſuppoſes the cauſe that we have aſſigned, that is to ſay, the motion of the currents of the ſea : ſecondly, becauſe the downs and hills which are formed from the matter which the ſea brings on its ſhores, are not compoſed of marble and hard ſtone, like common hills ; the ſhells are generally only foſſils, whereas in other mountains, the petrification is compleat; beſides the banks of ſhells and beds of earth, are not ſo horizontal in downs as in the hills compoſed of marble and hard ſtone. Theſe banks are more or leſs inclined there, as in the hills of Naſſrac, whereas in the hills and mountains which are formed under the water by the ſediment of the ſea, the beds are always parallel and very often horizontal, and the matters are petrified there as well as ſhells. I hope to evince that marble and other calcinable matters, which are almoſt all compoſed of madrepores, aſtroites and ſhells, have acquired at the bottom of the ſea the degree of hardneſs and perfection we ſee them in : on the contrary, gravel, ſoft ſtone and all ſtony matters, as incruſtations, ſtalactites, &c. which are alſo calcinable and found in the earth ſince our continent has been diſcovered, cannot acquire this degree of hardneſs and petrification which marble or hard ſtones have.

In the hiſtory of the Royal Academy of France for 1708, may be ſeen the obſervations of Monſieur Saulmon, on the ſubject of the *galets* found in many places, theſe galets are round and flat flints always very ſmooth, and which are driven aſhore by the ſea. At Bayeux and Brutel, which is a league from the ſea, we find thin ſtone by digging wells or

or pits. The mountains of Bonneuil, Broie and Quesney, which are about eighteen leagues from the sea, are all covered with; there are also some in the valley of Clermont in Beauvois. Monsieur Saulmon likewise relates, that a hole sixteen feet deep, bored direct and horizontally into the beach of Tresport, which is all of a soft nature disappeared in thirty years; that is to say, the sea had undermined the beach to the thickness of sixteen feet. By supposing that it always advanced alike, it would undermine 1000 fathoms or half a league of unhewn stone in 12000 years.

The motions of the sea are therefore the principal causes of the alterations which have happened and which do happen on the surface of the globe; but this cause is not the only one, there are many others which are less considerable that contribute to these changes: running waters, rivers, streams, the melting of snow, torrents, frosts, &c. have considerably changed the surface of the earth; the rain has diminished the height of the mountains, rivers and rivulets have raised plains, rivers have filled the sea to their mouths, the melting of snow and torrents have dug hollows in vallies, the frosts have split rocks and loosened mountains. We might quote an infinity of examples on the different alterations which all these causes have occasioned. Varenius says, that rivers convey into the sea, a great quantity of earth, which they deposit at a greater or less distance from the coasts, by reason of their rapidity; these earths fall to the bottom of the sea, and form at first those small banks which are every day increasing, cause shoals and at last form islands which become fertile and inhabited: this is the manner in which the islands of the Nile are formed, as well as those of St. Laurence, the Isle of Sanda, situate on the coast of Africa near the

the mouth of the river Coanga; the iſland of Norway, &c. See Varenni Geograph. p. 214. To theſe may be added the iſland of Tong Ming at China, which was formed by degrees by the earth which the river Nanguin waſhed away and depoſited at its mouth; this iſland is very conſiderable being more than twenty leagues long by five or ſix broad. See Lethes Edifiantes, Recueil xi. poge 234.

The Po, Trento, Atheſis, and many other rivers of Italy carry away with them a great quantity of earths into the canalsof Venice, eſpecially during the time of inundations, inſomuch that by degrees they fill up, are dry in many places at low water, and there is now only the canals, which are kept up at a great expence, that may be ſaid to have any depth.

At the mouth of the river Nile, at that of the Ganges and the Indus, at that of the river Plata at Brazil, at that of the river Nankin in China, and at the mouth of many other rivers, the earth and ſand are found accumulated. Loubere in his voyage to Siam ſays that the banks of ſand and earth daily increaſe at the mouths of the great rivers of Aſia, by the mud and ſediment they bring there; inſomuch that the navigation of theſe rivers become every day more difficult, and will one day be impaſſable: the ſame thing may be ſaid of the large rivers of Europe, and particularly of the Volga, which has more than ſeventy mouths in the Caſpian ſea; and the Danube, which has ſeven in the black ſea, &c.

As there is very ſeldom any rain in Egypt; the regular inundation of the Nile, proceeds from the torrent which fall therein in Ethiopia; it waſhes away agreat quantity of mud, and this river has not only brought on the land of Egypt many millions of annual beds, but has even thrown far into

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the ſea the foundations of an alluvion, which in time may form new land : for by the lead we find, at more than twenty leagues diſtance from the coaſt, the ſoil of the Nile at the bottom of the ſea, which is every year increaſing. Lower Egypt, where Della at preſent ſtands was formerly only a gulph of the ſea. See Diodorus de Succhas, lib. 3. Ariſtotle lib. 1. of Meteors, ch. 14. Herodotus, ſ. 4, 5, &c. Homer tells us, that the iſland of Pharos was twenty-four hours journey diſtant from Egypt, and it is known that at preſent it is almoſt contiguous to it. The ſoil of Egypt has not the ſame depth of good ground throughout its extent; the more we approach the ſea the leſs depth is found : near the borders of the Nile, there is ſometimes near thirty feet depth and upwards of good earth, whereas at the extremity of the inundation there is only ſeven inches. See Shaw's Travels, Vol. II. page 185 and 116. The town of Damietta is at preſent more than ten miles diſtance from the ſea, and in the time of St. Louis, in 1243, it was a ſea port. The town of Fooah which 300 years ago, was ſituate at the mouth of the Canopigua, a branch of the Nile, is at preſent more than ſeven miles diſtant from it ; within forty years the ſea has retreated half a league from before Roſette and Idern, pages 173 and 188.

All the great rivers of America, and even thoſe which have been lately diſcovered have ſuſered great alterations at their mouths. Father Clarlevoix ſpeaking of the river Miſſiſſipi ſays, that at the mouth of this river below New Orleans the country forms a point of land which does not appear to be very ancient, for by digging but a little into the earth we meet with water, and the quantity of ſmall iſlands which have been ſeen formed in the preſent time at all the mouths of this river, leaves

leaves not the leaſt doubt but that this neck of land was formed after the ſame manner. It appears certain, ſays he, that when Monſieur De la Salled went down (*a*) the Miſſiſſipi to the ſea, the mouth of this river was not as it this preſent time.

The nearer we approach towards the ſea, adds he, the more it becomes perceptible, the Barr has ſcarcely any water, in moſt of the ſmall outlets which the river has opened, and which have only multiplied ſo greatly, from the trees which are carried along with the currents, and one of which alone ſtopt by its branches or roots in a part where it is ſhallow, ſtops theſe ſands; I have ſeen, continues he, 206 leagues from New Orleans, piles of trunks of trees, one of which alone would have filled all the timber yards of Paris, therefore nothing is able to ſet them free: the mud which the river brings down ſerves them for cement and by degrees covers them: each inundation leaves a new ſtrata, and after ten years at moſt, ſhrubs and vegetables grow thereon: after this manner, moſt peaks and iſlands are formed, which ſo often change the courſe of a river. See Charlevoix Travels, vol. II. p. 440.

Neverthelesſs all the changes which rivers are the cauſe of are very ſlow, and cannot become conſiderable till after a long ſeries of years, but quick and ſudden changes have happened by inundations and earthquakes. The ancient Egyptian prieſts, 600 years before the birth of Chriſt aſſerted, according to the relation of Plato, that formerly there was a great iſland near Hercules's Pillar's, which was larger than Lybia, taken together; this iſland was called *Atlantide*, and was inunda-

(*a*) There are ſome Geographers who aſſert that Monſieur de la Salle, never went down the Miſſiſſippi.

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ted and submerged after a great earthquake. "Traditur Atheniensis civitas restitisse olim innumeris hostium copiis quæ ex Atlantico mari profectæ, proper cunctam Europam Asiamque obsederunt; tunc enim fretum illud navigabille, habens in ore & quasi vestibulo ejus insulam quas Herculis columnas cognominant: serturque insula illa Lybia simul & Asia major fuisse, per quam ad alias proximas insulas patebat aditus, atque ex insulis ad omnem continentem e conspecta jacentem vero mari vicinam; sed intra os ipsum portus augusto sinu traditur, pelagus illud verum mare, terra quoqne illa vere erat continens, &c. Post hæc ingenti terræ motu jugique diei unius & noctis illuvione factum est, ut terra dehiseens omnes illos bellicosos absorberet, & Atlantis insula sub vasto gurgite mergeretur. Plato in Timæo." This ancient tradition is not absolutely contrary to all probability, the earths which have been absorbed by the waters are perhaps those which join Ireland to the Acoras, and those to the continent of America, for in Ireland, the same fossils, the same shells, and the same marine productions are found as in America, some of which are different from those found in other parts of Europe.

Eusebius relates two testimonies on the subject of deluges, one of which is from Melon, who says that the plains of Syria had formerly been inundated; the other is from Abydenus, who says that in the time of king Sisithus there was a great deluge which had been predicted by Saturnus, Plutarch *De Solestia Animaluim.* Ovid, and other mythologists speak of the deluge of Deucalion, which was in Thessaly, about 700 years before the universal deluge. It is also asserted that there had been one more ancient in Attica, in the time of Ogiges, about 230 years before that of Deucalion.

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In the year 1095 there was a deluge in Syria, which drowned an infinite number of people. See Alfleda Chron. chap. 25. In 1165 there was so considerable a one in Friezland, that all the maritime coasts were submerged, with many millions of souls. See Krank, lib. 5. cap. 4. In 1218 there was another inundation which destroyed near an hundred thousand people, as well as that in 1530. There are a multitude of other examples of such great inundations, like that of 1604 in England, and many more.

A third cause of the change on the surface of the globe, are impetuous winds, they not only form downs and hills on the sea shores, and in the midst of continents, but they often stop, and choak up rivers, change their directions, tear up cultivated land, trees, overthrow edifices, and may be said to inundate entire countries: we have an example of these inundations on the coasts of Brittany in France: the history of the Royal Academy at Paris, anno 1722, makes mention of it in the following terms:

"In the environs of Saint Pol-de-Leon, in lower Brittany, there is a quarter near the sea, which before the year 1666 was inhabited, and is no longer, by reason of a sand which covers it to the height of more than twenty feet, and which projects and gains ground every year. By reckoning the given epocha it has gained upwards of six leagues, and is now more than about half a league from Saint Pol, so that according to all appearance in time the town must be deserted. In the submerged country we still see the tops of some steeples and chimnies which peep out of this sea of sand: the inhabitants of the interred villages have at least had sufficient time to quit their houses and have recourse to begging. page 7."

" It is the eaſt or north wind which increaſes this calamity, it raiſes up this ſand which is of a very fine nature, and ſweeps it away in ſuch a great quantity and with ſuch velocity, that Monſieur Deſlandes, to whom the academy is indebted for this obſervation, walking in that country during the time the wind is loaded with the ſand, he was obliged from time to time to wipe it off his hat and cloaths, becauſe they felt heavy. Beſides, when this wind is violent, it throws this ſand over a ſmall arm of the ſea into Roſcof, a ſmall port very much frequented by foreign veſſels : the ſand collects in their ſtreets to the height of two feet, and it is carted away. As we paſs along we may obſerve many ferrugineous parts in this ſand, which are diſcovered by a knife touched with the load-ſtone.

The part of the coaſt which furniſhes all this ſand, is a plain which extends from Saiut Pol as far as Ploueſcal, that is to ſay ſomewhat more than four leagues. The diſpoſition of the places is ſuch that there is only the eaſt wind or the north eaſt wind which has the direction neceſſary to convey the ſand over the lands. It is eaſy to be conceived how the ſand conveyed and accumulated by the wind in one part, is afterwards again taken up by the ſame wind and carried farther, and that the ſand can thus advance by ſubmerging the country, while the mine which furniſhes it, can furniſh it anew. For without this, the ſand by advancing would always diminiſh in height and would ceaſe its ravages. Now it is but too poſſible that the ſea throws up or depoſits for a long time new ſand in place of that from whence the wind raiſes it up ; it is certain it always ought to be very fine to be the more readily carried away."

" The

" The disaster is but of modern date, because the shoal which furnishes it, has not yet a sufficient quantity, to lift itself above the surface of the sea, or perhaps because the sea has not quitted that part and has left it uncovered only from such a time: it has had some motion on that coast, and at present reaches at high water half a league beyond certain rocks that formerly it never passed."

This unhappy quarter of the country inundated in so singular a manner justifies what the ancients and moderns relate concerning the tempests of sand, excited in Africa, which have destroyed whole towns and even armies.

" M. Shaw tells us, that the ports of Laodicea and Jebila, Tortosa, Rowadia, Tripoli, Tyre, Acre, and Jaffa, are all filled and heaped up with sand which have been driven by the great waves which beat on that side of the Mediterranean, when the west wind blows impetuously. See Shaw's Travels, vol. II.

It is useless to give a greater number of examples of the alterations which happen on land: fire, air and water produce continual changes thereon, which become very considerable by time: there are not only general causes, whose effects are periodical and regular, by which the sea successively takes the place of the earth and forsakes its dominions: but there is a greater number of particular causes which contribute to these mutations, and which produce inundations, sinkings in the surface of the earth, which as we well know is the most solid, like the rest of nature, undergoes continual and perpetual vicissitudes.

CONCLUSION,

OF THE

THEORY OF THE EARTH.

IT appears certain, that by the proofs we have given (Articles vii and viii,) that the terrestrial continents have been formerly covered by the sea; it appears also as certain (Article xii.) that the flux and reflux and other motions of the waters, continually detach from the side and the bottom of the sea, matters of every kind, and shells, some part of which deposit and fall to the bottom of the water as sediments, and which are the origin of the parallel and horizontal strata every where to be met with. It appears (Article ix) that the inequalities of the globe have no other cause than that of the motion of the sea, and that mountains have been produced by the successive masses and heapings of sediment we are speaking of, which have formed the different beds of which they are composed. It is evident that the currents which at first have followed the direction of these inequalities, have afterwards given to them all the figure which they at present preserve (Article

(Article xiii,) that is to ſay, that alternative correſpondence of the ſaillant angles always oppoſed to the returning angles. It appears likewiſe (Articles viii and xviii) that the greateſt part of the matters which the ſea has detached from its bottom and were in duſt when they were precipitated in the form of ſediments, and that this impalpable duſt has abſolutely and perfectly filled the inſide of ſhells, when theſe matters are found either of the ſame nature of ſhells, or of ſome analogous nature, it is certain (Article XXII) that the horizontal ſtrata, which have been produced by the waters, and which at firſt were in a ſoft ſtate, have acquired hardneſs in proportion as they became dry, and that this drying has produced perpendicular clefts, which croſs the horizontal ſtrata.

It is impoſſible to doubt after having ſeen the fact, which are related in the articles x, xi, xiv, xv, xvi, xvii, xviii, that an infinite number of revolutions, particular changes and alterations have happened on the ſurface of the globe, as well by the natural motion of the ſea, as by the action of rain, froſt, running waters, winds, ſubterraneous fires, earthquakes, inundations, &c. and that conſequently the ſea could not take the place of the earth, eſpecially in the earlieſt times after the creation, when the terreſtrial matters were much ſofter than they are at preſent. It muſt, neverthеleſs be acknowledged, that we can but very imperfectly judge of the ſucceſſion of natural revolutions; that we can ſtill leſs judge of the courſe of accidents, changes, and alterations: that the defect of hiſtorical monuments, deprives us of the knowledge of circumſtances, and experience and time is deficient to us: we do not pay any conſideration that this time which is wanting,

ting, is not ſo to nature: we would bring back to the moment of our exiſtence ages paſt and to come, without reflecting that this inſtant of time, nay even human life itſelf, extended as much as it can be with reſpect to hiſtory, is only a point in direction, a ſingle act in the hiſtory of the acts of the Almighty.

SUPPLEMENT

SUPPLEMENT

TO THE

NATURAL HISTORY.

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NATURAL HISTORY.

Obſervations and Experiments for the Improvement of Agriculture.

By Meſſrs. BUFFON and DU HAMEL.

THE phyſical ſtudy of vegetables, which leads us to the perfection of agriculture is one of thoſe ſciences, whoſe progreſs is only augmented by a multitude of obſervations, which can neither be the work of one man alone nor of a limited time; ſuch obſervations alſo ſeldom are of certain value till they have been repeatedly made and compared in

in different places, in different feafons, and by different perfons of fimilar ideas. It was in this view, that Meffrs. Buffon and Du Hamel joined together, to labour in concert for the eclairciffement of a number of phænomena difficult to be explained in the hiftory of nature, from the knowledge of which may refult an infinity of ufeful matters in the practice of agriculture.

The froft is fometimes fo intenfe during winter that it deftroys almoft all vegetables, and the fcarcity in the year 1709, is a melancholy epocha of its cruel effects.

Seeds entirely perifhed, as did fome kind of trees, &c. others, as olives and almoft all fruit-trees, fhared a milder fate, fhooting forth their leaves, their roots not having been hurt, In fhort, many large trees which were more vigorous, fhot forth almoft on every branch in fpring, and did not appear to have fuffered but very little. We fhall nevertheless remark the real and irreparable damage this winter occafioned them.

A froft which deprives us of the moft neceffary articles of life, which certainly deftroys many kinds of ufeful trees, and fcarcely leaves one infenfible of its rigour, is certainly one of the moft formidable: therefore, we have every thing to dread from one of thofe intenfe frofts, which might reduce us to the laft extremities if their effects were oftener felt; but, fortunately we can quote only two or three winters, which like that in 1709, produced fo great and general a calamity.

The greateft diforders which fpring frofts ever occafion, do not far touch fuch effential articles, although they damage the grain and principally the barley when it is but juft eared: this has never been obferved to produce great fcarcities: they do not affect the more folid parts of trees, nor the trunks

trunks or branches; but they totally deſtroy their productions and deprive us of the harveſt of the vines and orchards, and by the ſuppreſſion of the new buds, they cauſe a conſiderable damage to foreſts.

Although there are ſome examples, of the winter froſts having reduced us to a ſcarcity of bread and deprived us for many years of an infinity of uſeful things furniſhed us by vegetables: the damage which ſpring froſts occaſion, becomes ſtill more important, becauſe they afflict us much oftener: for as ſome froſts almoſt happen every year in that ſeaſon, ſo it rarely happens that they do not diminiſh our revenues.

To conſider the effects of froſt even very ſuperficially, we muſt perceive that thoſe produced by the ſharp froſts of winter, are very different from thoſe occaſioned by the ſpring froſts, ſince the one attacks the body itſelf and the moſt ſolid part of trees, whereas the others ſimply deſtroy their productions and oppoſe their growth, which will be more amply proved in the courſe of this memoir.

But we ſhall evince at the ſame time that they act in quite different circumſtances, and it is not always the ground, expoſition and ſituation in which the winter froſts are obſerved to have produced the greateſt diſorders and which ſuffer moſt from the ſpring froſts.

It will be readily conceived that we have not been able to make this diſtinctions of the effect of froſt, but by collecting many of the obſervations which will take up the greateſt part of this memoir. But may they not be ſimply curious, and may they not be of utility for thoſe who would dive into the phyſical cauſe of froſt? We hope for greater effects; that they will be profitable to agricul-

culture and that if they do not wholly put us in a method of entirely relieving us from the evils frosts occasion, they will afford a means to guard us partly from them : this is what we shall be careful of pointing out as our observations shall furnish us with opportunities. We shall therefore, immediately go upon the detail of them, beginning with that which regards the sharp frosts of winter and afterwards speak of those of spring.

We cannot reason with so great a certainty on winter frosts as those of spring; because, as we have already observed, we are happy enough seldom to meet with their tragical effects.

Most trees during this season being deprsved of blossoms, fruits and leaves, have generally their buds, hardened in a state of supporting very sharp frosts, at least, as the preceeding summer was cool; for, in this case, the buds being not arrived to that degree of maturity, which gardiners call *aoutes* (*a*) they are not in a state of resisting the moderate frosts of winter : but, this is not the general case and the buds are ofteneft ripe before winter and the trees endure the rigour of that season without being damaged, at least, unless excessive cold weather ensues, joined to the bad circumstance hereafter mentioned.

We have neverthelessmet with many trees in forests, attacked with considerable defects, certainly produced by the sharp frosts we speak of, and particularly by that of 1709 : for although that intense frost, begins to be termed old, it has produced in trees which it has not entirely destroyed, defects which will never be effaced.

These defects are, 1st, chaps or chinks which follow the direction of the fibres.

2d. A portion of dead wood included in the good.

Last,

(*a*) Ripened or filled with sap.

Laſtly, the double ſap which is an entire crown of imperfect wood: we muſt dwell a little on theſe defects and tell from whence they proceed. We ſhall begin with what concerns the double ſap.

The ſappy part of trees is as well known, a crown or circle of white and imperfect wood of a greater or leſſer thickneſs, and which in almoſt all trees is eaſily diſtinguiſhed from ſound wood, which is called the *heart*, by the difference of its colour and hardneſs: it is found immediately under the bark and ſurrounds the perfect wood, which in ſound trees, is nearly of the ſame colour, from the circumference to the center. But, in thoſe which we ſpeak of, the perfect wood is found ſeparated by another circle of white wood, inſomuch, that on cutting the trunk of one of the trees, we ſaw alternatively a circle of ſap, then one of perfect wood, and afterwards a clump of perfect wood, and more or leſs general according to the different ſoils and ſituations; inſtrong earth and in foreſt earth, it is ſcarcer and leſs conſiderable than in glades and light earth.

By the ſole inſpection of theſe cinctures of white wood, which we in future ſhall term *falſe ſap*, we perceive to be of bad quality; nevertheleſs, to be certain thereof, Monſieur Buffon had many planks ſawed two feet in length, by nine to ten ſquare, and having the like made from the true ſap, he had both broken by loading them in the middle, and thoſe of the falſe ſap always broke under a leſs weight than thoſe of the true, although as is well known, the ſtrength of the ſap is very trivial in compariſon of that of formed wood.

He afterwards took many pieces of theſe two kinds of ſap, he weighed them in the air, and afterwards in water, and he diſcovered that the ſpecific weight of the natural ſap was always greater than

than that of the falſe. He afterwards made a like experiment with the wood of the center of theſe ſame trees, to compare it with that of the cincture which is found between theſe two ſaps, and he diſcovered that the difference was nearly that which is naturally found betwixt the weight of the wood of the center of all trees and that of the circumference; thus, all that is become perfect wood in theſe defectuous trees, is found nearly in the common order. But it is not the ſame with reſpect of the falſe ſap, ſince, as the experiments prove, which we have juſt related, it is weaker, ſofter and lighter, than the true ſap, although it was formed twenty and twenty-five years before, which we have diſcovered by counting the annual circles, as well of the ſap, as of the wood which covers this falſe ſap; and this obſervation which we have repeated on a number of trees, proves inconteſtably that this defect is cauſed by the hard froſt of 1709: for we muſt not be ſurprized to find ſome coats leſs than the number of years which are elapſed ſince the year 1709, not only becauſe we can never by the number of lignous coats, find the age of trees within three or four years: but alſo becauſe the firſt lignous coat which were formed ſince the year 1709, were ſo thin and ſo confined, that we cannot very exactly diſtinguiſh them.

It is alſo certain, that it is the portion of the trees which was in ſap in the hard froſt of 1709, which inſtead of coming to perfection, and converting itſelf into wood, has on the contrary become more faulty: it cannot be doubted after the experiments made by M. de Buffon to aſcertain the quality of this falſe ſap.

Beſides, it is more natural to ſuppoſe, that the ſappy part of the wood muſt ſuffer more from ſharp froſts, than ſound wood; becauſe not only be-

being at the external part of the tree, it is more exposed to the weather; but also because it contains more sap, and the are fibres more tender and delicate than the wood. All this at first appears to wear but little difficulty, nevertheless, the objection related in the history of the Academy of Sciences, anno 1710, might be objected thereto; by which it appears that in 1709, the young trees have much better endured the hard frost than the old. But as the matter we relate is certain, there must be some difference between the organical parts, the vessels, the fibres, &c. of the sappy part of the old trees and of that the young; they perhaps will be more supple, insomuch, that a power which will be capable of causing the one to break, will only dilate the rest. On the whole, as these are matters which does not come under our inspection, and of which the mind remains but little satisfied, we shall pass more slightly over these conjectures, and content ourselves with the particulars we have well observed. This sappy part therefore has suffered greatly from the frost, it is an incontestible matter; but has it been entirely disorganized? This might happen without the death of the tree ensuing, provided the bark remained sound, and vegetation might continue. We daily see willows and limes which subsist only by their bark, and the same thing has been seen at the nursery of Roule, on an orange tree which died only a few years ago.

But we do not think that the false sap which we speak of is dead, it has always appeared to me in quite a different state from the sap found in trees, which has a portion of dead wood included in the sound, and which we shall speak of presently. It appeared the same to Monsieur Buffon, when he had the planks and cubes cut out for the experiments which we have related; and

besides, if it had been disorganized, as it extends over the whole circumference, it would have interrupted the lateral motion of the sap, and the wood of the center, which would be found recovered by this covering of the dead sappy part of the wood, not being able to vegetate would have also perished and altered, which was not the case, as the above experiment proves, and which I could confirm by many which I have executed with care, but of which I shall not speak at present, because they have been for other views: however, it is not easily conceived how this sappy part of wood has been changed so far as not to become wood, and that far from being dead, it was even in a state of supplying the lignous coats with sap, which are formed from above in a state of perfection, which may be compared to the wood of trees which have suffered no accident. This matter must nevertheless have been done in this manner, and the hard winter has caused an incurable malady to this part of the tree, for if it was dead as well as the bark which cloathed it, it is not doubtful but that the tree would have entirely perished, which is what happened in 1709 to many trees whose bark was detached from them, and which by the remaining sap in their trunk, have in spring shot forth their buds, but which died through weakness before autumn, in defect of receiving sufficient nutriment to subsist on.

We have met with some of these false sappy parts of trees which were thicker on one side than the other, which surprisingly agrees with the most general state of the sap. We have also seen others very thin, so that apparently there were only the outer coats injured. All these are not of the same colour, and have not undergone an equal alteration nor are of equal badness, which amazingly agrees with what we have before advanced. Having, at length, dug at the

the foot of ſome of theſe trees, to ſee if this defect exiſted alſo in the roots, but we found them ſound: therefore, it is probable, that the earth which covered them, had repaired the injury done by the froſt.

Here then we ſee one of the moſt dreadful effects of winter froſts, which locked up within the tree, is not leſs to be feared, ſince, it renders the trees attacked by them, almoſt entirely uſeleſs for all ſorts of buſineſs: but, beſides this, it is very frequent, and difficult to meet with trees totally exempt ftom them; nevertheleſs, we may deduce the obſervations we have juſt mentioned, that all has whoſe wood follows not one regular courſe from the center where it ſhould be of a deeper colour to the ſap, where the colour grows ſomewhat lighter, it ſhould be ſuſpected of ſome defects, and even to be entirely rejected for any event of conſequence, if the difference is conſiderable: let us, for the preſent ſay a word or two on the other defect.

By horizontally ſawing the feet of trees, we ſometimes perceive a piece of dead ſap or dried bark, entirely covered by the live wood: this dead ſap occupies nearly half of the circumferences in the part of the trunk where it is found: it is ſometimes browner than good wood, and at others almoſt white. This defect is found more frequently on the ſides expoſed to the ſouth, than in any other part. By the depth alſo where this ſap is found in the trunk, it appear in many trees to have periſhed in 1709; and we imagine it to be in all an event of the ſharp froſts in winter, which have cauſed a portion of the ſap and bark to be entirely periſhed, afterwards covered by the new wood, and this ſap is almoſt always found expoſed to the ſouth, becauſe the ſun melting the ice of this ſide, a humidity reſults which again freezes, ſoon after the ſun diſappears, which forms

forms a true ice, which as is well known, causes a considerable prejudice to trees. This defect does not generally take up the whole length of the trunk, so that we have seen square pieces which appeared very sound and which has only been found attacked in this frost bitten manner when they have been split, to be formed into planks or timbers, and if they had been used whole, they might have been thought exempt from all defects. It is nevertheless easily conceived, how such a disorder in their internal part must diminish their strength, and assist their perishing.

We have also said that the strong sharp winter frosts, caused the trees sometimes to split, according to the direction of their fibres and even with a report: therefore, it remains for us to relate the observations we have made on this accident.

In forests or woods we meet with trees, which having been split according to the direction of their fibres, are marked with a ridge formed by the cicatrix which has covered these cracks, and which remains within the trees without uniting again; because, as we shall take an opportunity to prove, a re-union is never formed in the lignous fibres as soon as they have been divided or broken. It is not to be doubted but that the sap which increases in volume when it freezes, as all liquors do, may produce many of these cracks. But we also suppose, there are some which are independent of the frost, and which are occasioned by a too great abundance of sap.

Be it as it may, we have found such defects in all soils and in all expositions, but more frequently than elsewhere in wet ground and northern and western expositions; this, perhaps may proceed in a case when the cold is more intense, to such expositions; and in the other, because these trees which are

are in marſhy grounds, have the tiſſue of their lignous fibres weaker and fewer, and becauſe their ſap is more abundant and aqueous than in dry land, which is the cauſe that the effect of the rarefaction of liquors by the pores, is more perceptible and ſo much the more in a ſtate of diminiſhing the lignous fibres, as they bring leſs reſiſtance thereto.

This reaſoning ſeems to be confirmed by another obſervation; which is, that reſinous trees, as the fir, are ſeldom injured by the ſharp froſts of winter, which may proceed from their ſap being more reſinous; for we know that oils do not perfectly freeze, and that inſtead of augmenting in volume in froſty weather like water, they diminiſh when they congeal.

Dr. Hales, that learned philoſopher, who has inſtructed us in ſo many things concerning vegetation, ſays, in his *Vegetable Statics*, p. 19. That the plants which tranſpire the leaſt, are thoſe which beſt reſiſt the winter; becauſe they have need only of a ſmall quantity of nutriment to preſerve themſelves. He proves likewiſe in the ſame part, that the plants, which preſerve their leaves during winter, are thoſe which tranſpire the leaſt: nevertheleſs, we know that the organ tree, the myrtle, and ſtill more the jeſſamine of Arabia, &c. are very ſenſible of froſt, although theſe trees preſerve their leaves during winter: we muſt therefore have recourſe to another cauſe to explain, why certain trees, which do not ſhed their leaves in winter, ſo well ſupport the ſharpeſt froſts.

On the whole, we have ſawed many trees attacked with this malady, and have almoſt always found, under the prominent cicatrix we have ſpoken of, a depoſit of ſap or rotten wood, and it is diſtinguiſhed from what are called in the foreſt terms, ſinks or gutters, only becauſe theſe defects which pro-

proceed from an alteration of the lignous fibres which is internally produced, has occaſioned no cicatrix to change the external form of trees, whereas the chinks produced by froſts, which proceed from a cleft afterwards covered by a cicatrix, forms a ridge or eminence in form of a cord, which announces the internal vice.

The ſharp winter froſts, produce without doubt many other injuries to trees, and we have likewiſe remarked many defects, which we might attribute to them with great probability; but, as we have not been able to be fully convinced of this; we ſhall add nothing more to what we have already ſaid, and ſhall paſs on to the obſervations we have made on the effects of ſpring froſts, after having ſpoken on the effects of the advantages and diſadvantages of different expoſitions with reſpect to froſt; for this queſtion is too intereſting to agriculture, not to en-endeavour its elucidation; ſo much the more, as authors are in oppoſition of ſentiment more capable of breeding doubts, than increaſing our knowledge. Some pretend that the froſt is felt more ſtrongly at the northern expoſition, while others aſſert it is more ſenſible to the ſouth or weſt, and all theſe opinions are founded on a ſingle obſervation. We neverthelcſs, thoroughly perceive what has cauſed this diverſity of opinions, and what has inclined us to reconcile them. But, before we relate the obſervations and experiments which have led us thereto, it is right to give a more exact idea of the queſtion.

It is not doubted but that it is at the northern expoſition that the greateſt cold proceeds, is in the ſhade of the ſun, which alone in ſharp froſts, tempers the rigour of the cold: beſides, it is expoſed to the north, north eaſt and north weſt winds, which are the coldeſt of all, not only to judge thereof by the

the effects which these winds produce on us, but also by the liquor of the thermometers, whose decision is much more certain.

We also observe, along our espaliers, that the earth is often frozen and hardened all the day towards the north, while it is possible to be worked upon towards the south.

After this, when a strong frost succeeds in the night, it is evident, that it must be much colder in the part where it is already formed, than in that where the earth is warmed by the sun; this is also the reason why even in hot countries; we also find snow in the northern exposition, on the back of lofty mountains: besides, the liquor of the thermometer always is lower at the northern exposition than to that of the south: therefore, it is incontestible, that it is colder and freezes stronger.

Does it require more to conclude, that the frost must occasion more disorder at this exposition than at that of the south? and we shall be confirmed in this opinion, by the observation we have before made on the cracks which follow the direction of the fibres, which we have found in greater quantity on this exposition than on all the rest.

In fact, it is certain, that all the accidents which solely depend on the power of the frost, such as that before-mentioned, will be found more frequently at the northern exposition than elsewhere. But is it always the great power of the frost which injures trees and is there not particular accidents, which causes a moderate frost to do them much more prejudice, than the much sharper frosts do when they happen in favourable circumstances.

We have already given an example thereof in speaking of that part of dead wood included in the good, which is produced by the hoar frost and which is found more frequently to the exposition of the south

ſouth than to all the reſt, and we well remember alſo that one part of the diſorders produced in the winter of 1709, muſt be attributed to a falſe thaw, which was followed by a froſt ſtill ſharper than that which had preceeded it; but, the obſervations we have made on the effects of ſpring froſts, ſupply us with many ſimilar examples which inconteſtibly proves that it is not to the expoſitions where it freezes the ſtrongeſt, that the froſt commits the greateſt injuries to vegetables. We ſhell enter into a detail of them, which will render the general propoſitions we have advanced apparent, and we ſhall begin by an experiment which M. Buffon has cauſed to be performed in his woods, ſituate near Montbard in Burgundy.

In the winter 1734, he cauſed a coppice of wood to be cut which meaſured one hundred and fifty fourfeet, ſituate in a dry place, on a flat ground, ſurrounded on all ſides with cultivable land. In this wood, he left many ſmall ſquare pieces without felling them and which faced the eaſt in a manner that each face exactly regarded the ſouth, north, eaſt and weſt. After having well cleared the part that was cut, he obſerved carefully in ſpring the growth of the young buds, principally on the renewed tops on the 20th April, it had ſenſibly ſhot out in the parts expoſed to the ſouth and which conſequently were ſheltered from the north by the tufted tops: it is in this part therefore that the buds ſhot forth the firſt and appeared the moſt vigorous, thoſe which were expoſed to the eaſt appeared later, the thoſe of the weſt, and laſtly thoſe of the northern expoſition.

The 28th of April, the froſt was felt very ſharply in the morning, by a north wind, the ſky was clear and the air very dry, eſpecially for three days.

He

He went to ſee in what ſtate the buds were in about the clumps, and found them ſpoiled and abſolutely blackened in all the parts expoſed to the ſouth and the ſhelter of the north wind, whereas thoſe which were expoſed to the cold north wind, which ſtill blowed, were only ſlightly injured, and he made the like obſervations around all the clumps he had reſerved. With reſpect to the eaſtern and weſtern expoſitions they were that day nearly alike injured.

The 14th, 15th and 22d of May, when it froze pretty ſharply by the north and northweſt winds, he likewiſe obſerved that all ſheltered from the wind were very much injured, whereas what had been expoſed to the wind, had ſuffered but very little. This experiment appeared deciſive and ſhewed that although it froze ſtrongly in parts expoſed to the north wind than to the reſt, the froſt nevertheleſs did leſs injury to vegetables.

This circumſtance is ſufficiently oppoſed to common prejudice: but it is not the leſs certain and even eaſy to be explained; it is ſufficient for this purpoſe to pay attention to circumſtances in which froſt acts, and we ſhall diſcover that humidity is the principal cauſe of its effects, ſo that all that may occaſion this humidity, renders at the ſame time the froſt dangerous to vegetables, and all that can diſſipate this humidity, if even it ſhould be done by increaſing the cold, for every thing that dries diminiſhes the diſaſters of a froſt, which we are going to confirm by obſervations.

We have often remarked that in low places, where miſts and fogs reign, froſt is felt more ſharply and oftener than elſewhere.

For inſtance in autumn and ſpring, we have ſeen delicate plants frozen in a kitchen garden, whereas the like plants, were preſerved found in another kit-

chen garden ſituated on an eminence; ſo likewiſe in vallies and low places of foreſts, the wood is never of a beautiful vein, nor of good quality, although the vallies are often on a better foundation than the reſt of the ground. The coppice wood is never good in low places, and although it ſhoots forth there later than elſewhere, by reaſon of a freſhneſs always concentrated therein, and which Monſieur de Buffon has aſſured me to have remarked even in ſummer. When he walked at night in the wood he felt almoſt as much heat on eminences as in the open plains, and in the vallies he was ſeized with a ſharp and diſquieting cold, although I affirm, that trees ſhoots out later in thoſe parts than elſewhere, theſe ſhoots are ſtill injured by the froſt, which ſpoiling the principal buds obliges the trees to ſhoot forth lateral branches, which renders them out of a ſtate of ever becoming handſome trees fit for ſervice; and what we have juſt advanced muſt not only be underſtood of deep vallies, which are ſo ſuſceptible of theſe inconveniencies which are remarked on northern expoſitions and thoſe incloſed on the ſouthern ſide in the form of an alley, in which it often freezes the whole year; but we ſhall alſo remark the ſame thing in the ſmalleſt vallies, ſo that by a little cuſtom, we can diſcover the bad figure of the ſhoots inclination of the earth; this is alſo what I have many times remarked and Mr. Buffon has particularly obſerved it the 28th of April 1734, for on that day the buds of all the trees of one year, unto the ſix or ſeventh, were frozen in all the lower places, whereas in the high and uncovered places, there were only the ſhoots near the earth which were ſpoiled, the earth was then very dry and the humidity of the air do not appear to him to have greatly contributed to this injury: the vines no more than the trees of the plain do not freeze: this

this might lead us to think that they are leſs delicate than the oak: but, we think this muſt be attributed to the humidity which is always greater in the woods than in the reſt of the plains; for we have obſerved that oaks are often very much injured from froſts in foreſts, while thoſe which are in the plains are not at all hurt.

In the month of May 1736, we have ſtill had opportunity twice to repeat this obſervation, which has even been attended with particular circumſtances, but which we are obliged to refer the detail to another part of this memoir, the better to evince the ſingularity of it.

Large timbers may cauſe the yonug trees which are near them, to be in the ſame ſtate as in the bottom of the valley: we have alſo remarked, that near large trees, the young wood is often more injured by the froſt than in parts remote from it; as in the midſt of ſuch wood and in woods where a great number of branches are left, it is felt with much greater force than in thoſe which are open. Now all the diſorders we are ſpeaking of whether in reſpect to vallies, whether becauſe formed along large timber, or covered by branches are not more conſiderable in theſe parts than in others, becauſe the wind and ſun cannot diſſipate the tranſpiration of the earth and plants, there remains a conſiderable humidity, which as we have obſerved, cauſe a very great prejudice to plants.

It is alſo remarked that the froſt is never more to be dreaded with reſpect to thevine flowers, buds of trees, &c. than when it ſucceeds miſts or even rain; however ſlight it may be: all theſe plants endure a very conſiderable cold without being damaged, when it has not rained for ſome time and the earth is very dry, as we have proved in that ſpring.

It

It is chiefly for the like reaſon that the froſts act more powerfully in places newly cultivated than elſewhere, and this becauſe the vapours which continually riſe from the earth, tranſpire more freely and abundantly from earth which is newly cultivated than from others. To this reaſon we muſt nevertheleſs ſubjoin that plants newly ſet, ſhoot forth more vigorouſly than others, which renders them more ſenſible and liable to the effects of froſt.

So likewiſe we have remarked that in light and ſandy ſoil, the froſt does more injury than in ſtrong land, and by ſuppoſing them of equal dryneſs, doubtleſs becauſe more exhalations eſcape from thoſe kinds of earths than from others, as we ſhall hereafter prove; and if a vine newly dunged is more ſubject to the froſt than another, is not from the humidity which eſcapes from it.

A furrow of vine which lies along a field of ſainfoin of peas, &c. is often all loſt by the froſt while the reſt of the vine is quite healthy, which muſt certainly be attributed to the tranſpiration of the ſainfoin or other plants which bring a humidity on the ſhoots of the vine.

In the vine alſo, the branches which are ſtrong and which are cut, are always leſs injured than the ſtock, eſpecially when not being attached to the props they are agitated by the wind which dries them.

The ſame thing is remarked in timber, and I have ſeen in copſes, all the buds entirely deſtroyed by the froſt, while the upper ſhoots had not received the leaſt damage. But Mr. Buffon has made the like obſervations with greater exactneſs; it always appeared to him that the froſt did more injury to one of earth than to two, inſomuch that it muſt be very

very violent to deſtroy the buds higher than four feet.

All theſe obſervations which may be looked upon as very conſtant, agree therefore to prove that it is not a ſharp froſt which ofteneſt injures plants loaded with humidity, which ſurpriſingly explains why it cauſes ſo many diſorders to the ſouthern expoſition, although it ſhould be leſs cold than that to the north, and as likewiſe the froſt cauſes more injury to the certain expoſition, than to all the reſt, when after a rain proceeding from a weſterly wind, the wind veers to the north towards ſun ſet, as often happens in ſpring, or when, by an eaſterly wind, a cold moiſt air ariſes before ſun riſe, which is not ſo common.

There are likewiſe circumſtances where the froſt does more injury to the eaſtern expoſition than to all the reſt; but, as we have many obſervations already on that ſubject, we ſhall firſt relate that we made in the ſpring froſt the 1736, which occaſioned ſo much damage. As it was very dry the ſucceeding ſpring, it froze for a long time before it injured the vines; but, it was not ſo in the foreſts, apparently, becauſe more humidity was perceived there than elſewhere; in Burgundy, it was the ſame as in the foreſt of Orleans, the underwood was injured very early. At laſt, the froſt ſo greatly increaſed, that all the vines were loſt in ſpite of the dryneſs which ſtill continued: but, inſtead of the froſt doing moſt damage under the ſhelter of the wind, on the contrary in the laſt ſpring, thoſe parts which were ſheltered were the only ones which were perceived, inſomuch, that many cloſes ſurrounded by walls, the ſtocks along the ſouthern expoſition were very green while all the reſt remained dry as in winter, and in two quarters the vines were ſaved, becauſe it was ſheltered from the north by a nurſery of aſh trees, and

and the other becauſe the vineyard was ſtocked with a number of fruit trees.

But this effect is very rare, and only happened from the ſeaſon being dry, and becauſe the vines had reſiſted the weather till the froſt became ſo ſtrong for the time of the year, that it could not injure the plants independent of the external humidity, and other particular circumſtances; it is at the northern expoſition that the greateſt damage is done, becauſe it is coldeſt to that expoſition.

But we imagine another cauſe for the diſorders which froſt produces more frequent to ſome expoſitions than to others; at the eaſt, for example more than to the weſt: this is founded on the following obſervations, which is as conſtant as the preceeding.

A ſharp froſt cauſes no prejudice to plants when it goes off before the ſun has ſtruck them: let it freeze at night, if the morning is cloudy, or if a ſlight rain falls; in one word, if by any cauſe ſoever, the ice melts gently and independent of the action of the ſun, it generally does no injury, and we have very often ſaved very delicate plants which had by chance remained expoſed to the froſts, by returning them into the green houſe before ſun riſe, or ſimply by covering them, before the ſun had ſhone upon them.

One time among the reſt, a very ſharp froſt happened in autumn, while our orange trees were out of the green houſe, and as it rained part of the night, they were all covered with icicles: this accident was recovered by covering them with cloths before the ſun roſe, ſo that there was only the young fruit, and the moſt tender ſhoots which were injured; and we are likewiſe perſuaded, that they would not have been ſaved if the covering had been thicker.

So likewiſe another year our *geranium*, and many other

other plants which cannot bear the froſt, where out when ſuddenly the wind which was ſouthweſt veered to the north and became ſo cold, that the rain water which had fell abundantly was frozen, and in a moment all that was expoſed to the air was covered with ice; we ſuſpected all our plants irrecoverable, nevertheleſs, we had them carried to the furthermoſt part of the green-houſe, ſhut up the windows and by this means they ſuſtained but little damage.

This precaution is obſervable in the practice for animals: when they are ſtricken with cold or a limb frozen, we take the precaution not to expoſe them to a briſk heat, but rub them with ſnow, dip them in water, or bury them in dung, in one word, we warm them gradually and with care.

So likewiſe, if we too precipitately thaw fruit, they periſh inſtantaneouſly, whereas they ſuffer leſs injury if they are thawed gradually.

To give an explanation how the ſun produces ſo many diſorders on frozen plants, ſome have imagined, that the ice, by melting, is reduced into ſmall ſpherical drops of water, which form ſo many ſmall burning mirrors when the ſun ſhines thereon; but, however ſmall the form of a mirror may be, it can only produce heat at a diſtance, and cannot produce any effect on a body it touches; beſides, the drop of water which is on the leaf of a plant, is flat on the ſide which touches the plant, which removes its focus to a greater diſtance. In ſhort, if theſe drops of water could produce this effect, why ſhould not the dew drops which are alſo ſpherical, produce the ſame? perhaps, it may be thought, that the moſt ſpirituous and volatile parts of the ſap melting the firſt, evaporate before the reſt were in a ſtate of moving in the veſſels of the plant, which might decompoſe the ſap.

But in general it may be ſaid, the froſt increaſ-

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ing the volume of the liquor, bends the veſſels of plants, and that the thaw cannot be performed without the parts which compoſe the frozen fluid, enter into motion. This change may be made with ſufficient gentleneſs not to break the moſt delicate veſſels of plants, which will by degrees return to their natural tone, and then the plants will not ſuffer any injury; but, if it is done with too much precipitation, theſe veſſels will not be able to retake their natural tone ſo ſoon, after having ſuffered a violent extenſion, the liquors will evaporate and the plant remain dry.

Although we might conclude with theſe conjectures, of which I am not perfectly ſatisfied, it always remains conſtant.

1. That in fruit, in ſpring or winter, it ſeldom happens that plants are injured ſimply by the great force of the froſt and independent of any particular circumſtances, and in this caſe it is at the northern expoſition that plants meet with the greateſt injury.

2. In froſty weather which laſts ſeveral days, the heat of the ſun melts the ice in ſome places for a few hours; for often it freezes again before ſun ſet, which forms an ice very prejudicial to plants, and it is obſervable that the ſouthern expoſition is more ſubject to this inconvenience than all the reſt.

3. It has been obſerved, that ſpring froſts principally diſorder thoſe places where there is humidity, the ſoil which tranſpires much, bottoms of vallies, and in general all places which cannot be dried by the wind and ſun, will be therefore more injured than others.

In ſhort, if in ſpring, the ſun which ſhines on frozen plants, occaſion a more conſiderable damage to them, it is clear that it will be the eaſtern expoſition

ſition, and next the ſouth which will ſuffer moſt from from this accident.

But, it will be ſaid, if this is the caſe, we muſt no longer plant to the ſouthern expoſition in *a-dos* (which are ſlopes or borders of earth thrown up in kitchen gardens or along eſpaliers) gilliflowers, cabbages, winter lettices, green peas, and other delicate plants we would have ſtand the winter, and preſerve for an early crop in ſpring; it will be to the northern expoſition that we muſt for the future plant peach and other delicate trees: it is proper to deſtroy theſe objections, and ſhew that they are falſe conſequences of what we have advanced.

Different objects are propoſed, when we ſet plants to live over the winter in ſhelters expoſed to the ſouth, and ſome times it is to expedite vegetation: it is, for example, in this intention, that along eſpaliers we plant ſome ranges of lettices, which from this reaſon are termed, *winter lettices*, which tolerably well reſiſt the froſt in whatever part we plant them, but which are more forward in this expoſition; at other times, it is to preſerve them from the rigour of this ſeaſon, with an intention of replanting them early in the ſpring: for example, it is this practice which is followed for winter cabbages, that are ſowed in this ſeaſon along an eſpalier border. This kind of cabbage, like brocoli, are tender and cannot endure the froſt, and would often periſh in theſe ſhelters if care was not taken to cover them during the ſharp froſts with ſtraw or dung ſupported on frames.

Again, we are ſometimes deſirous to forward the vegetation of ſome plants which will not bear the froſt, as green peas, &c. for which purpoſe they are planted on borders expoſed to the ſouth, beſides, which they are defended from ſharp froſts when the weather requires it.

It is well known, without being obliged to dwell

any longer on this point, that the ſouthern expoſition is more proper than all the reſt to accelerate vegetation, and we have ſhewn that this is alſo what is principally propoſed when ſome plants are ſet in this expoſition to live over the winter, ſince we are obliged, as we have obſerved, to employ, beſides this, coverings to guard plants which are delicate from the froſt; but, we muſt add, that if there are ſome circumſtances, where the froſt cauſes more diſorders to the ſouthern than to other expoſitions, there are alſo many caſes which are favourable to this expoſition: if, for example, in winter, there is any thing to fear from the ice, how many times does it happen that the heat of the ſun, which is increaſed by the reflection of the wall, has ſufficient force to diſſipate all the humidity, and then plants are almoſt in ſurety againſt the cold? beſides, how often does dry froſts happen, which unceaſingly act towards the north, and which are almoſt all not felt towards the ſouth? In ſpring likewiſe, we perceive that after a rain which proceeds from the ſouth weſt or ſouth eaſt the wind changes to the north, the ſouthern eſpalier being under the ſhelter of the wind, will ſuffer more than the reſt; but theſe caſes are very rare; and moſt often it is from rains which come from the norheaſt or northweſt, that the wind changes to the north and then the ſouthern eſpalier having been under ſhelter from the rain by the wall, the plants there will have leſs to ſuffer than the reſt, not only becauſe they have received leſs rain, but likewiſe becauſe it is always leſs cold there than in other expoſitions, as we have remarked at the beginning of this memoir.

Beſides, as the ſun dries much earth along the eſpaliers which are to the ſouth, the earth tranſpires there leſs than elſewhere.

It is well known, that what we have juſt advanced

ed, muſt have its application with reſpect to peach and apricot trees, which it is cuſtomary to put in this expoſition and in that of the eaſt. We ſhall only add, that it is not uncuſtomary to ſee peach trees frozen in the eaſt and ſouthern expoſitions, and not to be ſo even in the weſt or north : but independent of this, we can never rely on having many nor good peaches in this laſt expoſition : great quantity of bloſſoms fall off entirely without ſetting ; others, after having ſet fall, from the trees, and thoſe which remain with difficulty arrive to maturity. I have an eſpalier of peach trees in a weſtern expoſition, a little declining to the north, which almoſt affords no fruit, although the trees are handſomer than thoſe to the ſouthern and northern expoſition.

Therefore, we cannot avoid the inconveniences, which may be reproached to the ſouthern expoſition with reſpect of the froſt, without feeling others that are worſe.

But all delicate trees, as fig, laurel, &c. muſt be ſet to the ſouth, taking care, as is generally done to cover them ; we ſhall only remark that dry dung is preferable for this purpoſe to ſtraw, which never ſo exactly covers it, and in which ſome grain always remains that attracts moles or rats, which ſometimes eat the barkof trees to quench their thirſt in froſty weather, when they can meet with no water to drink, nor herb to feed upon which has happened to us more than once or twice ; but, when we make uſe of dung it muſt be dry, without which it will heat and make the young branches grow mouldy.

All theſe precautions, are nevertheleſs very inferior to the eſpaliers in niches, as may be ſeen in the Royal Gardens of France ; in this manner plants are ſheltered from all winds, except that of the ſouth which cannot hurt them ; the ſun which warms theſe

place

places during the day, prevents the cold from being so violent during the night, and over these defended places we may put a slight covering with great facility, which will hold the plants there in a state of dryness, infinitely proper to prevent all the accidents which the spring frosts and ice might produce, and most plants will not suffer from being deprived of their external humidity, because they scarcely transpire at all in winter, no more than in the beginning of spring, so that the humidity of the air is sufficient for their supply.

But since the dew renders plants so susceptible of the spring frost, might we not hope that the researches which Messrs. Muschenbrock and Fay have made on this matter, might turn out to the profit of agriculture? For, in short, since there are bodies which seem to attract dew, while there are others which repel it; if we could paint, plaister, or wash the walls with some matter which might repel the dew, it is certain we should have room to hope for a more fortunate success, than from the precaution taken to place a plank in form of a roof, over the espaliers, which can scarcely diminish the abundance of the dew on trees, since Monsieur du Fay has proved that often it does not fall perpendicularly like rain, but floats in the air and attaches itself to bodies it meets with: so that often as much dew is amassed under a roof as in places entirely open. It would be easy for us to revise all our observations and continue to deduce useful consequences to the practice of agriculture: what we have said, for example, must determine to root up all trees which prevent the wind from dissipating mists.

Since by cultivating the earth, we cause more exhalations to issue, we must pay greater attention not to cultivate them in critical times.

We

We must expresly forbid from sowing kitchen plants on vine furrows, which by their transpiration hurt the vine.

Props should be put to the vines as late as possible.

The hedges, which border the vines on the north side, should be kept lower than the rest.

It is preferable to improve vines with mould rather than dung.

Lastly, If we are inclined to chuse a soil, we should avoid those which are in bottoms or in ground which transpire much.

A part of these precautions may be also usefully employed for fruit trees; with respect, for example, for plants, which gardiners are forward to put at the feet of their bushes and along their espaliers.

If there are some parts high and others low in a garden, we should pay attention to sow spring and delicate plants on elevated parts, at least, if we do not design to cover them with glasses, &c. for in the case where humidity cannot hurt them, it might be often advantageous to chuse low places to be sheltered from the north and north west winds.

We may also profit from what has been said to the advantage of forests, for if we mean to make reserve of any, it will never be in parts where the frost causes so much damage.

If we plant a tree, we should pay attention to put in vallies, trees which can endure the frost better than oak.

When any considerable fall of timber is made, we should make them in roads, beginning always on the north side, in order that the wind which generally blows in frosty weather, may dissipate that humidity which is so prejudicial to the underwood.

There might be also many other useful consequences

quences drawn from our obſervations ; but we ſhall content ourſelves with having recounted ſome, becauſe, the ingenious man may ſupply what we have omitted by paying a little attention to the obſervations we have mentioned. We are well convinced there are a greater number of experiments to be made on this matter : but we have thought it no ways inconvenient to relate thoſe we have made : perhaps, even they will engage ſome perſon to work on the ſame ſubject, and if they do not produce their effect, they will not prevent us from purſuing the views which we have on this matter.

Of

Of the Cause of the Excentricity of the lignous Coats perceived, when the Trunk of a Tree is cut horizontally.

OF THE

Inequality of Thickness and of the different Number of these Coats, as well in Timber compleatly formed as in the sappy Part of the Wood.

By Messrs. BUFFON and DU HAMEL.

WE can never labour more usefully in physics, than by investigating doubtful circumstances and by establishing the true origin of those which are attributed to imaginary or insufficient causes. It is in this view that Mr. Buffon and I have undertaken many researches in agriculture: that we have, for example, made observations and experiments on the growth and support of trees, their disorders and defects, on the plantation and re-establishment of forests, &c. We began to render an account of the success of our labour to the Academy, by the examination of a matter which almost all authors of agriculture mention; but which (we do not hesitate to say) has been only foreseen, and for which reason has been attributed to causes very remote from truth.

All the world knows that, when the trunk of an oak is cut horizontally, for example, we perceive in the heart and sap lignous circles which surround it; these circles are divided from each other by

other

other lignous circles of a ſubſtance more rare, and it is theſe laſt which diſtinguiſh and divide the growth, of each year. It is natural to ſuppoſe, that without particular accidents, they ought to be nearly of an equal thickneſs and equally remote from the center.

It is nevertheleſs quite otherwiſe and moſt authors who have treated on agriculture who have diſcovered this difference, have attributed it to different cauſes, and have deduced divers conſequences from it : ſome, for example, will have that we carefully examine the ſituation of young trees in the nurſery, to ſet them facing the eaſt in the place deſſtined for them which gardiners term *compaſs planting*, they hold that the ſide of the tree, which was oppoſed to the ſun in the nurſery, ſuffers infallibly when it is expoſed there.

Others will have that the lignous circles of all trees are excentrical and always more remote from the center and axis of the trunk of the ſouth ſide than of the north, which they propoſe to travellers who might be loſt in woods, as a certain means of finding their road.

We have thought it our duty to aſſure ourſelves of theſe two circumſtances, and to diſcover whether trees tranſplanted ſuffer when they are in a contrary ſituation to that which they had in the nurſery, we choſe fifty aſpins which had been raiſed in a vineyard, and not in a nurſery, in order to have ſubjects whoſe expoſition was well decided. I raiſed all theſe trees to a like height, the trunk being twelve or thirteen inches in circumference and before we rooted them up, I marked a ſmall notch on the ſouth ſide, after which I planted them in two lines : obſerving to put them alternatively, one in the ſituation in which it was raiſed and the other in a contrary ſituation, inſomuch, that I have had twenty-

twenty-five trees ſet towards the eaſt as in the vineyard to compare with twenty-five others which were in quite an oppoſite ſituation: by planting them thus alternatively, I have avoided every ſuſpicion which might have ariſen concerning the veins of the earth, whoſe quality ſometimes changes all at once. My trees are ready to give their third ſhoots, I have well examined them, and there does not appear to me to be any difference between one and the other; it is probable that there will not be any hereafter; for, if the change of expoſition muſt produce any thing, it can only be in the firſt years and till the trees are accuſtomed to the impreſſions of the ſun and wind, which is ſaid to be capable of producing a ſenſible effect on theſe young ſubjects.

We ſhall, nevertheleſs, not decide that this attention is ſuperfluous in all caſes; for, we ſee in light earths, peach and apricot trees very high, planted in eſpaliers to the ſouth entirely dries towards the ſide of the ſun and ſubſiſts only by the ſide of the wall. It ſeems therefore that in hot countries, or the ſouth ſlope of mountains, the ſun may produce a ſenſible effect on the part of the bark which is expoſed to it, but my experiments inconteſtibly decides that in our climate and common ſituations, it is uſeleſs to tranſplant trees to an eaſtern direction. This is always an attention, which at leaſt, only confuſes when we plant trees in a row, for provided the trunks are a little crooked, they cauſe a great deformity when we have not judgment to place the curvature in the lineal direction of the row.

With reſpect to the excentricity of the lignous coats towards the ſouth, we have remarked that the compleateſt people in the arragement of foreſts, do not agree in this point. All in part agree with the

excentricity of the annual coats, but ſome pretend that they are thicker on the northern ſide, becauſe they ſay, the ſun dries the ſouth ſide, and they reſt their opinon on the quick growth of trees of the northern countries which grow quicker than thoſe of the ſouth.

Others, on the contrary, which compoſe the greateſt number, pretend to have obſerved that the coats are thicker on the ſouth ſide, and to add a phyſical reaſoning to their obſervations, they ſay, that the ſun being the principal mover of the ſap, muſt determine it to paſs more plentifully in the part where it has the greateſt action, while the rain which often proceeds from a ſouth wind moiſtens the bark, nouriſhes it, or at leaſt prevents the drying which would have been done by the ſun.

Theſe therefore, are the matters in doubt between thoſe even who are in actual employ of managing timber, and we muſt not be aſtoniſhed thereat. For different circumſtances produce different varieties. We ſhall prove it by many experiments, but before we relate them, it is right to forewarn, that in this place we diſtinguiſh oaks into two kinds, viz. thoſe which bear acorns with long ſtalks, and thoſe which are almoſt tied to the branch. Each of theſe kinds affords three others, oaks which bear very thick acorns and thoſe of a moderate ſize, and laſtly, thoſe whoſe acorns are very ſmall. This diviſion which would be imperfect to a botaniſt, is ſufficient to a forreſter, and we have adopted it, becauſe we perceived ſome difference in the quality of timber of theſe kinds, and beſides, in our foreſts there is a very great number of different oaks whoſe timber is abſolutely ſimilar, to which conſequently we have had no reſpect.

EX-

EXPERIMENT I.

The 27th of March 1734, where the trees grew on the ſouth ſide more than on the north, M. de Buffon, cauſed a large acorn oak to be cut about ſixty years old, about one and a half foot above the ſurface of the ground, that is to ſay, in the part where the branch commences to be round, for the roots of trees always cauſe trees to enlarge in breadth at their feet : this was ſeated in a border open to the eaſt, but a little covered on one ſide to the north, and on the other to the ſouth. He cauſed the ſtroke to be made as horizontally as poſſible, and having placed the point of the compaſs in the center of the annual circles, he diſcovered that it coincided with that of the circumferences of the tree, and that all the ſides were of equal thickneſs : but, having cauſed this tree to be cut twenty feet higher, the ſide of the north was thicker than that of the ſouth ; he remarked that there was a large branch on the north ſide, a little below twenty feet.

EXPERIMENT II.

The ſame day he cauſed a ſmall acorn oak, to be cut in like manner, a foot and a half above the earth, aged about eighty years, ſituate like the preceding : it was thicker on the ſouth ſide than on the north. In this tree he obſerved a very hard knot on the north ſide which came from the roots.

EX-

EXPERIMENT III.

The ſame day, he cauſed an acorn oak of a moderate ſize, to be cut, aged ſixty years, in a part opened to the ſouth ; the ſouth ſide was ſtronger than that of the north, but it was much leſs than that of the eaſt. He dug at the foot of the tree and perceived that the thickeſt root was on the eaſt ſide, he afterwards cut this tree two feet higher, that is to ſay, near four feet from the earth, and at this height the north ſide was thicker than all the reſt.

EXPERIMENT IV.

The ſame day he cut a large acorn oak about the ſame weight, about ſixty years old, in a part expoſed to the eaſt, and found it of equal thickneſs on all ſides ; but a foot and a half higher, i. e. three feet above the ground, the ſouth ſide was thicker than of the north.

EXPERIMENT V.

Another large acorn oak, about thirty-five years old, expoſed to the eaſt, had increaſed more than one-third in thickneſs, on the ſouth ſide than on the north : but, a foot higher, this inequality diminiſhed, and a foot higher was of equal thickneſs on every ſide : nevertheleſs by taking it higher the ſouth ſide was a little ſtronger.

EXPERIMENT VI.

Another large acorn oak, aged thirty-five years, expoſed to the ſouth, cut three feet above the earth, was a little ſtronger to the ſouth than to the north, but

but much ſtronger in the eaſt than on any other direction.

EXPERIMENT VII.

Another oak of the ſame kind and acorn, ſituate in the middle of the wood, was equally grown on the ſouth and on the north ſides, but more on the eaſt than on the weſt.

EXPERIMENT VIII.

The 29th of March 1734, he continued theſe trials, and cut a large acorn oak, at a foot and a half above the earth; the tree was handſome and forty years old, expoſed to the ſouth, it had increaſed in ſize on the north ſide, much more than on any other, that of the ſouth was even weakeſt of all, having dug at the foof of a tree, he found the thickeſt root on the north ſide.

EXPERIMENT IX.

Another oak of the ſame kind, alike in age and poſition, cut at the ſame height of a foot and a half above the ſurface of the ground, had increaſed on the ſouth ſide more than on the north, he dug the earth away at the foot, and found a thick root on the ſouth ſide, but none appeared at the north ſide.

EXPERIMENT X.

Another oak of the ſame kind, but ſixty years old and abſolutely iſolated, was thicker on the north ſide than on any other. By digging the thickeſt on the north ſide.

To

To these obſervations I might ſubjoin many other like them which M. de Buffon cauſed to be executed in Burgundy, as well as a great number which I made in the foreſt of Orleans, which amounted to more than forty trees but the detail of which appeared to me to be uſeleſs. It is ſufficient to ſay that they all afforded the deciſion that the ſouth or north aſpect, is not all the cauſe of the excentricity of the lignous coats, but that it muſt be attributed rather to the poſition of the roots and branches, inſomuch, that the lignous coats are always thicker at the ſide where there are more or ſtronger roots. Nevertheleſs we muſt not fail of relating an experiment which M. de Buffon has made and which is abſolutely deciſive.

The ſame day the 29th of March, he choſe an iſolated oak, to which he remarked was four roots nearly equal, and pretty regularly diſpoſed, ſo that each very nearly anſwered to one of the four cardinal points and having cut it almoſt a foot and a half above the ſurface of the ground, he found, as he ſuſpected, that the center of the lignous coats coincided with that of the circumference of the tree, and that conſequently it had increaſed in thickneſs on all ſides.

What has fully convinced us that the true cauſe of the excentricity of the lignous coats, is the poſition of the roots, and ſometimes of the branches, and that of the ſouth or north aſpect, &c. influenced the trees to make them grow unequal, it can be only in an inſenſible manner; ſince in all theſe trees, ſometimes the lignous coats of the ſide was the thickeſt, and ſometimes thoſe of the north, or of any other ſide; and that when we have cut trunks or trees at different heigths, we found the lignous coats, ſometimes thicker on one ſide than on the other.

This

This laſt obſervation has engaged me to ſplit many trees in the middle: in ſome, the heart followed the axis of the trunk nearly in a right line; but in the greateſt number, even in the moſt perfect timber of the beſt grain, he made inflexions in a zig zag form; beyond that in the center of almoſt all trees, I have remarked, as well as M. de Buffon, at the thickneſs of an inch, or of an inch and an half towards the center, there were many ſmall knots, ſo that the wood was only formed free from them beyond that ſlight thickneſs.

Theſe knots doubtleſs proceed from the eruption of the branches, that the oak ſhoots forth abundantly when young, and which periſhing, is covered over in time, and form theſe ſmall knots; to which we muſt partly attribute that irregular direction of the heart which is unnatural to trees. It may alſo proceed from their having loſt their inclination in their youth, either by the froſt, cattle, power of the wind, or ſome other accident, for they are then obliged to nouriſh the laternal branches, and the heart of theſe branches not anſwering that of the trunk, a change of direction is made: it is true, that by degrees theſe branches are again ſupplied; but there always remains an inflexion in the heart of theſe trees.

We have not therefore perceived that the expoſition any ſenſible effect on the thickneſs of the lignous coat, and we ſuppoſe that when more is remarked on one ſide, than on the other, it almoſt always proceeds from the inſertion of the roots, or from the eruption of ſome branches, whether theſe branches actually exiſt, or that having periſhed, their place is covered over. The cicatrix wounds, ſhakes, and double ſap, in a tree, may likewiſe produce this augmentation of thickneſs in the lignous coats; but we do not abſolutely think it independent of the expoſition, we ſhall ſtill prove by many familiar obſervations.

OB-

OBSERVATION I.

It may have been univerſally remarked in orchards, that trees have had one branch ſtrong and vigorous, while the reſt remained weak and languiſhing. If we dig at the foot of theſe trees to examine their roots, we ſhall find nearly the ſame thing as above the earth, that is to ſay, that on the ſide of the vigorous branch, there will be vigorous roots, while thoſe on the other ſide will be bad.

OBSERVATION II.

If a tree is planted between a cultivated and an uncultivated piece of land, generally the part of the tree on the cultivated ſide will be greener and more vigorous, than that on the other.

OBSERVATION III.

We often find a tree loſe a branch ſuddenly, and if we dig at the foot of it, we generally find the cauſe of this accident, in the bad condition in which roots are found, which anſwered to the periſhed branch.

OBSERVATION IV.

If the thick root of a tree is cut, as is ſometimes done to make it bear fruit, or to prevent it only flouriſhing on one of its branches, that part of the tree which correſponds to the root languiſhes; but it does not always happen, that it is that part we are deſirous of weakening, becauſe we are not always certain to what part of a tree the root carries its nutriment, and one and the ſame root often carries it

to

to ſeveral branches; we ſhall ſpeak of this matter ſhortly.

OBSERVATION V.

Let a tree be ſplit from one of its branches, through its trunk, as far as one of its roots, we ſhall remark that the branches, are formed like a bundle of fibres which are a continuation of the longitudinal fibres of the trunk of the tree.

All theſe obſervations ſeems to prove that the trunks of trees are compoſed of different bundles of longitudinal fibres, which by one end anſwers to a root, and by the other ſometimes to one, and at other times to many branches; ſo that each bundle of fibres appears to receive its nutriment from the root, of which it is a continuation. According to this, when a root periſhes, the drying of a bundle of fibres muſt follow in one part of the trunk, and in the correſponding branch, but it muſt be remarked:

1ſt. That in this caſe the branches only languiſh, and do not entirely die.

2d. That having grafted a branch of a ſtrong, flouriſhing elm in the middle, which was loaded with other ſmall branches, the boughs which were on the lower part of the grafted branch, ſhoot out, though much weaker than thoſe of the ſubject; and I have ſeen at the Charteux de Paris, an orange tree grow in this ſituation four or five months on the wild ſtock where it had been grafted. Theſe experiments prove that the nutriment which is driven to one part of a tree is communicated to all the reſt, and conſequently the ſap has a motion of lateral communication. On this ſubject we may ſee the experiments of Dr. Hales, but this lateral motion does not ſo greatly hurt the direct motion of the

the ſap, to prevent it from going in greater abundance to the part of the tree, and even to the bundle of fibres, which correſponds to the root which ſupplies it ; and this is the cauſe that it principally diſtributes itſelf to one part of the branch of the tree, and that we commonly ſee the part of a tree to which a vigorous root correſponds, increaſe more than all the reſt, as may be remarked in trees on the borders of foreſts, for their beſt roots being almoſt always on the ſide of the field, is the reaſon that the lignous coats are commonly the thickeſt on that ſide.

Therefore it appears by the experiments above related, that the lignous coats are thicker in the parts of the tree where the ſap has been carried in greateſt abundance, whether it proceeds from the roots or the branches, for it is known that both act in concert for the motion of the ſap.

It is this abundance of ſap which cauſes the ſappy part of wood to transform ſooner into timber : from this depends the relative thickneſs of ſound timber from the ſappy part in different ſoils, and in divers kinds ; for the ſappy part is no other than imperfect timber, a timber leſs denſe, which has need for the ſap to paſs through it, and depoſit the fixed parts to fill up its pores, and render it like timber : the part in which the ſap lies will paſs in greateſt abundance, will be therefore that which will moſt readily transform itſelf into ſound wood, and this transformation in the ſame kinds, muſt follow the quality of the ſoil.

EXPERIMENTS.

M. DE BUFFON cauſed many oaks to be ſawed at two or three feet diſtance from the earth, and hav-

having ſmoothed the place where it was cut with a plain, he made the following remarks :

An oak 46 years old, had 14 annual coats of ſappy wood on one ſide, and on the other it had 20 : nevertheleſs the 14 coats were $\frac{1}{4}$ thicker than the 20 on the other ſide.

Another oak which ſeemed to be of the ſame age, had 16 coats of ſappy wood on one ſide, and on the oppoſite 22 : nevertheleſs the 16 coats were $\frac{1}{4}$ thicker than the 22.

Another oak of the ſame age, had 20 coats of ſappy wood on one ſide, and on the oppoſite 24 : nevertheleſs the 20 coats were $\frac{1}{4}$ thicker than the 24.

Another oak of the ſame age, had 10 coats of ſappy wood on one ſide, and on the oppoſite 15 : nevertheleſs the 10 coats were $\frac{1}{4}$ thicker than the 15.

Another oak of the ſame age, had 14 coats of ſappy wood on one ſide, and on the other 21 : nevertheleſs the 14 were almoſt twice as thick as thoſe of the 21.

An oak of the ſame age, had 11 coats of ſappy wood on one ſide, and on the oppoſite 17 : nevertheleſs the 11 were almoſt twice as thick as thoſe of the 17.

He made ſimilar obſervations on the three kinds of oaks, which are generally found in woods and perceived no difference.

All theſe experiments prove that the thickneſs of the ſappy part of wood is ſo much the greater, according as the number of coats which form it is leſs. This circumſtance appears ſingular, the explanation of it, however, is very eaſy ; to render it clearer, let us for a moment ſuppoſe, that only two roots are left to a tree, the one to the right, double that which is to the left, if we pay no atten-

tention to the lateral communication of the ſap, the right ſide of the tree would receive as much nutriment again as the left, the annual circles would thicken therefore more to the right than to the left; and at the ſame time the right part of the tree would be more readily transformed into perfect wood than the left, as it would depoſit in the interſtices of the ſappy wood a greater number of fixed parts proper to form timber.

It therefore appears to us perfectly proved, that among many trees planted in the ſame ſoil, thoſe which grow the faſteſt have their lignous coats thickeſt, and that at the ſame time their ſappy part is ſooner converted into wood, than in trees which grow but ſlowly. We ſhall now ſhew that oaks which have grown in poor ground have more ſappy wood, in proportion to the quantity of their wood, than thoſe which grow in rich ground. Effectively, if the ſappy part is not converted into perfect timber, but in proportion as the ſap which traverſes it, depoſits fixed parts therein, it is evident that the ſappy wood, will be much longer before it is converted into timber in poor ground than in rich.

Trees which grew in the part where there was a leſs quantity of good earth, were not ſo thick, their lignous coats were thinner than the reſt: there was a greater number of ſappy coats, and generally even more ſappy wood in proportion to the thickneſs of the wood; I ſay in proportion to the wood, for if we meaſure with a rule, we ſhall commonly find it much thicker in good ground than in the other.

M. de Buffon has purſued theſe obſervations ſtill farther, for having felled in a dry and gravelly ſoil, a great number both of the middling and ſmaller acorn oaks, all about 46 years old: he alſo felled

felled as many oaks of the same kind and same age in a good soil, where the wood crowned later: these two soils are about a pistol shot from each other, in the same exposition, and differ only in quality and depth of good earth, which is in one some feet, and in the other only eight or nine inches. With a rule and compass we took the measures of all these different trees, and after having made a table of them all, we found:

1. That at the age of 46 years, the common or middling sized acorn oak in poor ground, had one part of sappy wood and $2 + \frac{2}{9}$ of heart, and the small acorn oak one part sappy wood and $1 + \frac{2}{16}$ of heart, therefore in poor ground the first has twice the heart of the last.

2. That at the age of 46 years, the common oaks in good ground had one part of sap and $2\frac{1}{2}$ heart; therefore, in good ground, the first has $\frac{1}{6}$ more heart than the last.

3. That at the same age of 46 years, the common oaks in a poor soil had 16 or 17 lignous sappy coats, and the small acorn oaks had 21; therefore, the sappy part is sooner converted into heart in the common oaks, than in the small acorn oaks.

4. That at the age of 46 years, the thickness of serviceable timber, comprehending the sappy part of the small acorn oak in bad ground, is to the thickness of serviceable wood of oaks of the same kind in good ground as $21\frac{1}{2}$ are to 29; from whence by supposing the heights equal, we reckon the proportion of serviceable wood in good ground to the quantity in bad, as 841 to 462, that is to say, nearly

nearly double: and as trees of the ſame kind riſe in proportion to the goodneſs and depth of the earth, we may be aſſured that the quantity of wood which a good ſoil furniſhes is much more than double that produced in bad ground. We here ſpeak only of ſerviceable wood, and not at all of underwood: for, after having made the ſame trials and experiments, and the ſame calculations on trees much younger, as from 25 to 30 years, in good and bad ground, we have found that the differences were not by far ſo great; but as this detail would be rather too long, and as beſides, ſome experiments enter therein on the ſappy part, and the heart of oak according to the different ages, on the abſolute time the ſappy part requires to transform itſelf into heart, and on the produce of poor ground, compared to the produce of good ground, we ſhall refer it to another opportunity.

It is not therefore to be doubted, but that in poor ground, the ſappy part is thicker in proportion to the wood, than in good ground, and although we ſhould here only ſpeak of the proportion of ſound trees, nevertheleſs we ſhall remark *en paſſant* that thoſe which were a little damaged, had always more ſappy wood than the reſt. We alſo took the ſame proportion of the heart and ſappy wood in oaks of different ages, and have diſcovered that the lignous coats were thicker in young trees than in old, but alſo that there were a much leſs quantity. Let us therefore conclude from our obſervations and experiments:

1. That in all caſes where the ſap is carried in greater abundance, the lignous coats as well as the ſappy are thicker, whether from the abundance of this ſap is an effect of the goodneſs of the ground, or of the good conſtitution of the tree, or that it de-

depends on the age of a tree, or the position of the roots, branches, &c.

2. That the ſappy part is converted ſo much the ſooner into wood, as the ſap is carried in greater abundance in trees, or in one portion of theſe trees than in another, which follows from what we have juſt advanced.

3. That the excentricity of the lignous coats depends entirely on the abundance of the ſap, which is found greater in one portion of the tree than another, which is always produced by the vigour of the roots or branches, which anſwer to the parts where the coats are the thickeſt, and fartheſt from the center.

4. That the heart of the tree very rarely follows the axis of the trunk, which is ſometimes produced by the unequal thickneſs of the lignous coats, which we have juſt mentioned; and ſometimes by the wounds covered over, or from extravaſions of ſubſtance, and often by accidents which have cauſed the aſcending principle to periſh.

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MAN can only judge of the nature and extent of the univerſe, by the ſimple relation of his ſight: to him the earth is a ſolid, whoſe volume is unbounded, and whoſe extent is without limits; of which he can only with trouble ſurvey ſmall ſuperficial ſpaces; while the ſun, planets and the immenſity of the heavens, preſent to his eyes, only luminous points, of which the ſun and moon appear to him to be the only objects worthy to fix his regards. To this falſe idea on the extent of the nature, and proportions of the univerſe, is preſently joined the ſtill more diſproportionate ſentiment of pretention: man by

by comparing himſelf with other terreſtrial beings, finds himſelf the firſt, hence he preſumes that all was made for him: that the earth was created only to ſerve him for an habitation, and the heaven for a ſpectacle; that in ſhort, the whole univerſe ought to yield to his neceſſities, and even his pleaſures. But in proportion as he makes uſe of that divine light, which alone ennobles his being, in proportion as he gains more inſtruction, he has been forced to abate his pretenſions; he finds himſelf leſſened in proportion as the univerſe increaſes on him, and it becomes demonſtrable to him, that this earth which forms all his domain, and on which unfortunately he cannot ſubſiſt without trouble and ſorrow, is in proportion as ſmall with reſpect to the univerſe, as he is with reſpect to the Creator. In fact, it is no longer poſſible to doubt, that this earth ſo large and extenſive as it is, is but a moderate ſized planet, a ſmall maſs of matter, which circulates along with others around the ſun: that this body of light and fire is no more than 1,200,000 times larger than the globe of the earth, and that its power does not extend to all the bodies which circulates round it: inſomuch that our globe being 33 millions of miles at leaſt diſtant from it, the planet of Saturn is found to be 313 millions of miles diſtant, from which we cannot help concluding that the extent of the ſun's empire, that king of nature, is a ſphere, whoſe diameter is 627 millions of leagues, whereas that of the earth is only 2865: and if we take the cube of theſe two numbers, we ſhall demonſtrate that the earth is ſmaller relative to this ſpace, than a grain of ſand is relative to the whole volume of the globe.

However the planet of Saturn, although the fartheſt from the ſun, is not near the confines of his empire: the limits extend much farther, ſince comets

mets beyond that diſtance, paſs over ſpaces which may be eſtimated by the period of the time of their revolutions: a comet which like that of the year 1680 circulates round the ſun in 575 years, is 15 times more remote from that body, than Saturn is diſtant from it; for the great axis of its orbit is 138 times greater than the diſtance from the earth to the ſun. Hence we muſt ſtill augment the extent of the ſolar power 15 times the diſtance from the ſun to Saturn, ſo that all the ſpace in which the planets are included is only a ſmall province of the domain of this body, whoſe bounds ſhould be placed at leaſt 138 times the diſtance from the ſun to the earth, that is to ſay, 138 times or 34 millions of leagues.

What immenſity of ſpace! What quantity of matter! For independent of the planets, there probably exiſts 4 or 500 comets, perhaps larger than the earth which run over the different regions of this vaſt ſphere in all directions, the terreſtrial globe only conſtituting a part thereof, a unity on 191, 201, 612, 985, 514, 272,000, a quantity repreſented by theſe numbers, but which imagination cannot attain nor comprehend. Is this not ſufficient to render us, our poſterity, and our great habitation, ſmaller than atoms?

Nevertheleſs this enormous extent, this vaſt ſphere is yet only a very ſmall ſpace in the immenſity of the heavens; each fixed ſtar is a ſun, a center of a ſphere quite as vaſt; and as we reckon more than 2000, perceived by the naked eye, and as with teleſcopes we can diſcover ſo much thegreater number as theſe inſtruments are more powerful; the extent of the univerſe appears to be without bounds, and the ſolar ſyſtem forms only a province of the univerſal empire of the Creator; an infinite empire like himſelf.

Sirius

Sirius the moſt brilliant fixed ſtar, and which for that reaſon may be regarded as the neareſt ſun to ours, affords to our ſight only a ſecond of annual parallax on the whole diameter of the earth's orbit, 6771770 millions of leagues diſtance from us, that is to ſay, at 6767216 millions from the limits of the ſolar ſyſtem, ſuch as we have aſſigned them after the depth to which comets immerge. Suppoſing therefore that there is an equal ſpace from Sirius to that which belongs to our ſun, we ſtill ſhall perceive that we muſt ſtill farther extend the limits of our ſolar ſyſtem 742 times more than it at preſent is, as far as the aphelion of the comet, whoſe enormous diſtance from the ſun is nevertheleſs only a unit on 742 of the total diameter of the ſolar ſyſtem.

Diſtance from the earth to the ſun	33 mill. of leagues
Diſtance from Saturn to the ſun	313 ditto
Diſtance from the aphelion of the comet to the ſun - - - - - -	4554 ditto
Diſtance from Sirius to the ſun -	677170 ditto
Diſtance of Sirius to the point of the aphelion of the comet, ſuppoſing that in aſcending from the ſun the comet pointed directly towards Sirius (a ſuppoſition which diminiſhes the diſtance as much as poſſible) - - - - - - - - -	6767216 ditto
One half the diſtance from Sirius to the ſun, or the depth of the ſolar and ſircin ſyſtem - - - - -	3385885 ditto
Extent beyond the limits of the comet's aphelion - - - - - -	3381331 ditto
Which being divided by the diſtance of the comet's aphelion, gives about - - - - - - - - - -	742 ½

We

We can form another idea of the immenſe diſtance from Sirius to us, by recollecting that the ſun's diſk forms to our ſight an angle of 32 minutes, whereas that of Sirius forms only that of a ſecond; and Sirius being a ſun like ours, which we ſhall ſuppoſe of equal magnitude, ſince there is no more reaſon to ſuppoſe it larger or ſmaller, it would appear to us as large as the ſun, if it was but at a like diſtance. Taking therefore two numbers proportional to the ſquare of 32 minutes, and to the ſquare of a ſecond, we ſhall have 3686400 for the diſtance of the earth to Sirius, and one for its diſtance to the ſun; and as this unit is equal to 33 millions of leagues, we ſee how many millions of leagues Sirius is diſtant from us, ſince we muſt multiply theſe 33 millions by 3686400, and if we divide the ſpace between theſe two neighbouring ſuns, although at ſo a great a diſtance, we ſhall ſee that the comets might be removed to a diſtance 1800000 times greater than that of the earth to the ſun without quitting the limits of the ſolar univerſe, and without being ſubjected to other laws than that of our ſun, and hence it may be concluded that the ſolar ſyſtem for its diameter has an extent, which, although prodigious, nevertheleſs forms only a very ſmall portion of the heavens; and we muſt infer a truth therefrom but little known, which is, that from all the points of the planetary univerſe, that is to ſay, from the ſun, earth, and all the other planets, the ſky muſt appear the ſame.

When in a ſerene and fine night we contemplate all thoſe ſtars with which the celeſtrial vault is illuminated, it might be imagined that by being conveyed into another planet more remote from the ſun than it is from the earth, we ſhould ſee theſe glittering ſtars larger, and emitting a brighter light, ſince

ſince we ſhould ſee them nearer to us. Neverthe-leſs, the kind of calculation, we have juſt made, demonſtrates that if we were placed in Saturn, i. e. nine or ten times further from our ſun, and 300 millions of leagues nearer Sirius, it would appear to us no bigger than the one 124021ſt part, an augmentation abſolutely inſenſible: from which it muſt be concluded, that the heaven with reſpect to all the planets, has the ſame aſpect as it has to the earth.

Therefore if even there ſhould exiſt comets whoſe periods of revolution might be double, treble or decuple the period of 575 years, the longeſt known to us: if even the comets in conſequence thereof, immerge at a depth ten times greater, there would ſtill be a ſpace 74 or 75 times deeper to reach the laſt confines, as well of the ſolar ſyſtem, as of the ſyrian; ſo that by allowing Sirius as much magnitude as our ſun has, and ſuppoſing in his ſyſtem as many or more cometary bodies then there are comets exiſting in the ſolar ſyſtem, Sirius will govern them as the ſun governs his, and there will remain an immenſe interval between the confines of the two empires; an interval which appears to be no more than a deſert in the vaſt ſpace, and which muſt give a ſuſpicion that cometary bodies do exiſt, whoſe periods are longer, and which are to a much greater diſtance than we can determine by our actual knowledge. Sirius might alſo be a ſun much larger and more powerful than ours: and if that is the caſe, it muſt throw the borders of his domain ſo much the farther back by approaching them to us, and at the ſame time retrench the circumference of the ſun.

We cannot here avoid preſuming in fact, that in this very great number of fixed ſtars, which are all ſo many ſuns, there are ſome greater and others ſmaller

ſmaller than ours, others more or leſs luminous, ſome nearer which are repreſented to us by thoſe ſtars called by aſtronomers, *Stars of the firſt magnitude*, and many others more remote, which for that reaſon appear to us ſmaller: the ſtars called *nebulous*, ſeem to want light and fire, and to be, as I may ſay, only half-lighted; thoſe which appear and diſappear alternatively, have perhaps a form flattened by the violence of the centrifrugal force in their motion of rotation: theſe ſuns are perceived when they are in the full and diſappear when they are ſideways. In this grand order of things, and in the nature of the ſtars, there are the ſame varieties, and the ſame differences, in number, ſize, ſpace, motion, form and duration: the ſame relation, the ſame degrees, and the ſame connection as are found in all the other orders of the creation.

Each of the ſuns being endowed like ours, and like all matter, with an attractive power, which extends to an indefinite diſtance, and decreaſes as the ſpace increaſes, analogy leads us to think that within the ſphere of each of theſe luminous ſtars, there exiſts a great nnmber of opaque bodies, planets or comets which circulate round them but which we perceive only by conception, ſince being obſcure and much ſmaller than the ſuns which ſerve them for heat, they are beyond the reach of our ſight, and even all which can extend or perfectionate it.

It might therefore be imagined that comets paſs from one ſyſtem to the other, and if they are found on the confines of the two empires, they will be attracted by the preponderating power, and forced to obey the laws of a new maſter. But, by the immenſity of ſpace which is beyond the aphelion of our comets, it appears that the ſovereign ruler has ſeperated each ſyſtem by deſarts a thouſand

and a thousand times larger than all the extent of known spaces. These desarts of which numbers cannot fathom the depth of, are eternal and invincible barriers, which all the powers of created nature cannot surmount. To form a communication from one system to the other, and for the subjects of one empire to pass into the other, it would be requisite that the seat of the throne was not immoveable; for the fixed star or rather the sun, the king of this system changing place, would draw with it in its course all the bodies which depend thereon, and hence might approach and invade another demesne. If its rout was directed towards a weaker star, it would commence by carrying off the subjects of its most distant provinces, afterwards those more interior, and would oblige them all to increase its train by revolving round it, and its neighbour thus deprived of its subjects, no longer having planets nor comets would at the same time lose both its light and fire, which their motion alone can excite and support : hence this isolated star being no longer maintained in its place by the equilibrium of its forces, would be obliged to change nutrition, by changing nature, and becoming an obscure body would like the rest obey the power of the conqueror, whose fire would increase in proportion to the number of its conquests.

For what can be said on the nature of the sun, but that it is a body of prodigious volume, an enormous mass of matter penetrated by fire, which appears like a metal or a solid body in incandescence ? And from whence can this constant state of incandescence, this continually renewed production of fire proceed, whose consumation does not appear to be supported by any aliment, and whose deperdition is null, or at least insensible, although constant for such a great

great number of years? Is there, or can there be any other caufe of the production of this permanent fire, but the rapid motion from the ftrong preffure of all bodies, which revolve round this common heat, and which heats and embraces it, like a wheel rapidly turned round its axis? The preffure, which they exercife by virtue of their weight is equivalent to the friction and is even more powerful, becaufe this preffure is a penetrating power, which not only rubs the external furface, but all the internal parts of the mafs: the rapidity of their motion is fo great, that the friction acquires a force almoft infinite, and confequently fets the whole mafs of the axis; in a ftate of incandefcence, light, heat, and fire, which from hence has no need of aliment to be fupported, and which in fpite of the deperdition each day made by the emiffion of light, may remain for ever and ever without any fenfible alteration: other funs rendering as much light to ours, as it fends to them, and no part of the fmalleft atom of fire, or any other matter foever, being loft in a fyftem where all is attracted.

If from this fketch of the great table of the heavens, which I have only attempted to reprefent to myfelf the proportion of the fpaces, and that of the motion of bodies which travel over them: if from this point of view, to which I only raifed myfelf more clearly to fee how greatly nature muft be multiplied in the different regions of the univerfe, we defcend to that proportion of fpace which we are better acquainted with, and in which the fun exercifes its power, we fhall difcover that although by its power it governs all bodies which are in it, it neverthelefs has not the power of vivifying them, nor even the power of fupporting vegetation and life.

Mer-

Mercury who of all bodies revolving round the ſun, is the neareſt to it, nevertheleſs receives only a heat $\frac{50}{8}$ times ſtronger than that of the earth, and this heat $\frac{50}{8}$ times ſtronger than the heat ſent from the ſun to the earth, very far from being burning as it has always been ſuppoſed, would not be ſtrong enough to ſupport animated nature, for the actual heat of the ſun of the earth, being only $\frac{1}{50}$ part of that of the heat of the terreſtrial globe, that of the ſun on Mercury conſequently is $\frac{50}{400}$ or $\frac{1}{8}$ part of the actual heat of the earth. Now if we ſubſtract from the $\frac{3}{4}$ and $\frac{1}{2}$ the heat which is at preſent the temperature of the earth, it is certain that animated nature would be much ſtopt, if not entirely extinguiſhed: and ſince the ſun alone cannot maintain organized nature in the neareſt planet, by a ſtronger reaſon, how much would it not require to animate or vivify thoſe which are at a greater diſtance from it? To Venus it only ſends a heat $2_{50}\frac{1}{50}$ times ſtronger than that it ſends to the earth, and this heat $2_{50}\frac{1}{50}$ times greater than that of the ſun on the earth, very far from being ſtrong enough to ſupport animated nature, would not certainly ſuffice to ſupport the liquidity of water, nor perhaps even the fluidity of air, ſince our actual temperature would be refrigerated to $\frac{2}{49}$ or $\frac{2}{24\frac{1}{2}}$ which is very near the term $\frac{1}{25}$ which we have given as the external limit of the ſlighteſt heat, relative to living nature. And with reſpect to Mars, Jupiter, Saturn, and all their Statellites, the quantity of heat which the ſuns ſends to them in compariſon with that which is neceſſary for the ſup-

ſupport of nature, which be looked upon as a nul effect, eſpecially in the two larger planets, which nevertheleſs appear to be the eſſential objects of the ſolar ſyſtem.

All the planets, without excepting Mercury, might therefore be, and always have been volumes (as large as uſeleſs) of matter more than dead, profoundly frozen, and conſequently places inhabited from the earlieſt times, and inhabitable for ever if they do not include within themſelves treaſures of a fire much ſuperior to that they receive from the ſun. This quantity of heat which our globe poſſeſſes of itſelf, and which is 50 times greater than the heat which comes to it from the ſun, is in fact the treaſure of nature, the true fund of fire, which animates us, as well as every being : it is this internal heat of the earth which cauſes all things to germinate, and all to develop : it is that which conſtitutes the element of fire, properly called an element, which alone gives motion to other elements, and which if it was reduced to $\frac{1}{50}$ could not conquer their reſiſtance, and would itſelf fall into an inertia ; now this element, this ſole active power, the ſole which may render the air fluid, the water liquid, and the earth penetrable, might it not have been given to the terreſtrial globe alone ? Does anagoly permit us to doubt that the other planets do not likewiſe contain a quantity of heat, which belongs to them alone, and which muſt render them capable of receiving and ſupporting living nature ? Is it not greater and more worthy the idea we ought to have of the Creator, to ſuppoſe that there every where exiſts beings, who acknowledge his power and celebrate his glory, than to depopulate all the univerſe, excepting the earth, and to deſpoil it of all beings, by re-

reducing it to a profound ſolitude, in which we ſhould only find a deſart ſpace, and frightful maſſes of matter entirely inanimate. .

It is therefore neceſſary, ſince the heat of the ſun is ſo ſmall on the earth, and on the other planets, that all poſſeſs a heat which ſolely belongs to them, and we ſhould make our reſearches from whence this heat proceeds which alone can conſtitute this element of fire in each of the planets. Now where ſhall we be able to diſcover this great quantity of heat, if it is not in the ſource itſelf of all heat, in the ſun alone, and the matter of which the planets have been formed and projected by a ſole and like impulſion, will have preſerved their motion in the ſame direction and their heat in proportion of their magnitude and denſity. Whoever will weigh the value of theſe analogies, and will conceive the power of their relations, will not doubt but that the planets have iſſued from the ſun, by the ſtroke of a comet, becauſe in the ſolar ſyſtem there are only comets that are ſufficiently powerful, and of ſufficient motion to be able to communicate a ſimilar impulſion to maſſes of matter which compoſe the planets. If to all theſe circumſtances on which I have founded this hypotheſeſis we unite the new circumſtance of the innate heat of the earth, and of the inſufficiency of that of the ſun to ſupport nature, we ſhall reſt perſuaded, as I am, that in the time of their formation, the planets and earth were in a ſtate of liquefaction, afterwards in a ſtate of incandeſcence, and at laſt in a ſucceſſive ſtate of heat, always decreaſing from incandeſcence to actual temperance.

For otherways is there any mode of conceiving the origin and duration of this heat proper to the earth ? how to imagine that the fire termed central

ral can, in fact, subsist at the bottom of the globe, without air, that is to say, without its first aliment and from whence this fire should proceed, which is supposed to be shut up in the center of the globe, what origin, what source shall we find for it? Descartes, has already imagined the earth and planets were only small incrusted suns, that is to say, entirely extinguished. Liebnitz, have not hesitated to pronounce that the terrestrial globe owes its source and the consistence of its matters to the element of fire: and, nevertheless these two great philosophers, had not by far, so many circumstances, so many observations, which has been acquired and collected in our days; these circumstances are actually so very numerous and so well established, that it appears to me more than probable, that the earth as well as the planets have been projected out of the sun and consequently of a like matter, which, at first, being in a state liquifaction, have obeyed the centrifugal power, at the same time as it collected itself together by that of attraction, which has given a round form to all the planets under the equator, and flattened under the poles, by reason of the variety of their rotation; that afterwards this fire being by little and little dissipated, the benign temperature and suitable to organised nature has succeeded either sooner or later in different planets, according to the difference of their thickness or density. And if even there should be other particular causes of heat assigned for the earth and planets, which might combine with those whose effects we have calculated, our results are not less curious, nor less useful to the advancement of science. We shall hereafter speak of these particular causes of heat: all that can here be said, not to complicate objects is, that these particular causes

cauſes may ſtill prolong the time of the refrigeration of the globe and the duration of living nature, beyond the terms we have indicated.

But, it may be aſked me, is your theory as equally well founded in every point which ſerves it for baſe ? It is certain, according to your experiments, that a globe as big as the earth, and compoſed of the ſame matters, cannot refrigerate from incandeſcence to actual temperature, but in 74000 years, and, that in order to heat it to the point of incandeſcence, a 15th of this time would be required, that is about 5000 years ; and alſo, it would be requiſite for this globe to be ſurrounded all this time by the moſt violent fire ; hence there are, as you may ſay, ſtrong preſumptions that this great heat of the earth could not communicate to it from a diſtance, and that conſequently the terreſtrial matter formerly made a part of the maſs of the ſun ; but it does not appear equally proved that the heat of this body on the earth, is at preſent but $\frac{1}{50}$ 750 part of the heat of the globe. The teſtimony of our ſenſes ſeems to refute this opinion, which you lay down as a certain truth, and although we cannot doubt that the earth has not an innate heat, which is demonſtrated by its always equal temperature in all deep places where the coldneſs of the air cannot communicate ; does it reſult that this heat, which appears to us as moderate temperature, is nevertheleſs greater than the heat of the ſun which ſeems to burn us ?

I can give full ſatisfaction to all theſe objections ; but muſt previouſly reflect on the nature of our ſenſations. A very ſlight and often imperceptible difference in the reality or in the proportion of cauſes which affect us, produces a great

a great number in their effects. Is there any thing nearer extreme pleasure than grief, and who can assign the distance between the lively sensation which delightfully moves us, and the friction which hurts us, between the fire which warms and that which burns, between the light which is agreeable to our sight and that which blinds us, between the savour which pleases our taste and that which displeases it, between the smell, a small dose of which at first agreeably affects us and presently after nauseates us. We must therefore cease from being astonished that a small augmentation of heat, such as $\frac{1}{50}$ can appear to us so striking, and that the limits of the greatest heat in summer, to the greatest cold in winter is between seven and eight, according to M. de Amontons, or between 31 and 32 as M. de Marian has found it to be by comprehending all the results of the observations made on this subject, during 56 years successively.

But it must be owned that if we would judge of the real heat of the globe, after the accounts which this last author hrs given of the emanations of the terrestrial heat to the accessions of the solar heat in this climate, it would be found that their relation being nearly : : 29 : 1 in summer and : : 471 or even : : 491 in winter; it would be found, I say, by joining these two relations, that the solar heat to the terrestrial heat would be only : : $\frac{1}{500}$: or : : $\frac{1}{250}$: 1. But this estimation would be faulty, and the error would become so much the greater as the climates should be colder. It is therefore only between the equator and the tropics, where the heat being almost equal in all the seasons of the year, that we might with found-

ation eſtabliſh the proportions between the heat of the emanations of the earth and the acceſſions of the ſolar heat. Now this relation in all this vaſt climate, where the ſummers and winters are almoſt equal, is nearly : : 50 : 1. This is the reaſon I have adopted this propoſition, and made it the baſis of the calculation of my enquiries.

However, I do not pretend poſitively to aſſert that the innate heat of the earth is really 50 times greater than that which comes to it from the ſun: as this heat of the globe belongs to all terreſtrial matter, if we compare a part, we have no proportion by which we ſeperate it, nor conſequently any ſenſible and real limits to which we might relate it. But even if it ſhould be thought that the ſolar heat was greater or ſmaller than we have ſuppoſed it, relative to the terreſtrial heat, our theory would only alter the proportion of the reſults.

For example, if we include the whole extent of our ſenſations of the greateſt heat to the greateſt cold, within the limits given by the obſervations of M. Amontons, that is to ſay, between ſeven and eight, or in $\frac{1}{8}$ and that at the ſame time we ſhould ſuppoſe that the heat of the ſun can alone produce this difference of our ſenſations; we ſhall from thence have the proportion of 8 to 1 of the innate heat of the terreſtrial globe to that which proceeds from the ſun, and conſequently the compenſation which this heat of the ſun actually makes on the earth, would be $\frac{1}{8}$ and the compenſation which it made in the time of incandeſcence will have been $\frac{1}{200}$: adding together theſe two terms, we have $\frac{26}{200}$ which multiplied by $12\frac{1}{2}$, the half of the ſum of all the terms of the diminution of heat, gives

gives $\frac{325}{200}$ or $\frac{5}{8}$ for the total compenſation made by the ſun's heat during the period of 74047 years of the refrigeration of the earth to actual temperature. And as the total loſs of the innate heat is to the total compenſation, in the ſame ratio as the time of the period of refrigeration, we ſhall have $25 : 1\frac{5}{8} :: 74047 : 4813\frac{1}{25}$ ſo that the refrigeration of the globe of the earth inſtead of having been prolonged only 770 years, would have been $4813\frac{1}{25}$ years; which joined to the longeſt prolongation which the heat of the moon would alſo produce in this ſuppoſition, would give more than 5000 years.

If we adopt the limits laid down by M. de Mairan, which are from 31 to 32, and ſuppoſe that the ſolar heat is no more than $\frac{1}{32}$ of that of the earth, we ſhall have only $\frac{1}{4}$ of this prolongation, that is to ſay about 1250 years, inſtead of 770 which gives the ſuppoſition of $\frac{1}{50}$ which we have adopted.

But on the contrary, if we ſuppoſe that the ſun's heat is only $\frac{1}{250}$ of that of the earth, as appears to reſult from the obſervations made at Paris, we ſhould have for the compenſation of the incandeſcence $\frac{1}{6250}$ and $\frac{1}{250}$ for the compenſation to the end of the period of 74047 years of the refrigeration of the terreſtrial globe to actual temperature, and we ſhould find $\frac{17}{250}$ for the total compenſation made by the heat of the ſun during this period, which would give only 154 years, that is to ſay, the 5th part of 770 years for the time of the prolongation of refrigeration. And likewiſe, if in the place

place of $\frac{1}{50}$ we ſuppoſe that the ſolar heat was $\frac{1}{10}$ of of the terreſtrial, we ſhould find that the time of prolongation would be five times longer, that is to ſay, 3850 years : ſo that the more we endeavour to increaſe the heat which comes to us from the ſun relative to that which emanates from the earth, the more we ſhall extend the duration of nature, and date the antiquity of the world further back : for by ſuppoſing the heat of the ſun was equal to the innate heat of the globe, we ſhould find that the time of prolongation would be 38504 years, which conſequently gives the earth a greater antiquity of 38 or 39000 years.

If we caſt our eyes on the table which M. de Mairan has calculated with great exactneſs, and in which he gives the proportion of the heat which comes to us from the ſun, to that which emanates from the earth in all climates, we ſhall diſcover a well atteſted fact, which is, that in all climates where obſervations have been made, the ſummers are equal, whereas the winters are prodigiouſly unequal : this learned phyſician attributes this conſtant equality of the intenſity of heat in ſummer in all climates, to the reciprocal compenſation of the ſolar heat, and from the heat of the emanations of the central fire : " This is not, (he ſays, page 253) an affair of choice, ſyſtem, or conveniency, that this inverted rout alternatively decreaſing and increaſing of the central emanations of the ſolar ſummers, it is the circumſtance itſelf, &c. ſo that according to him, the emanations of the heat of the earth increaſes or decreaſes preciſely in the ſame ratio, as the action of the ſun's heat increaſes or decreaſes in different climates and as this proportion of increaſe and decreaſe between the terreſtrial and the ſolar heat, appears to him, with reaſon, very ſurpriſing

prising according to his theory, and at the same time he cannot doubt of the fact; he attempts to explain it, by saying, " that the terrestrial globe being at first a small paste of earth and water, turning round its axis and continually exposed to the rays of the sun, according to all the annual aspects of the climates, will be hardened towards the surface, and so much the deeper, as its parts are more exactly exposed to it. And if a harder, more compact, thicker, and in general a more impenetrable soil, becomes in these same relations an object so much the greater to the emanations of the internal fire of the earth, AS IS EVIDENT MUST HAPPEN; hence is not these obstacles in a direct ratio of the different heats of the solar summer, and the central emanations in an inverted ratio of the same heat? And that this therefore is nothing more than the universal inequality of summers? For supposing these obstacles or their retrenchments of heat made at the constant and primitive emanation, expressed by the value of the solar summers, that is to say, in the most perfect and visible state of all the proportionalities, EQUALITY; it is clear that we do not retrench so greatly on one side as we add to the the other, and that consequently the sums or summers will he always and every where alike. See therefore (adds he) this surprising equality of summers of all climates in the earth brought back to an intelligible principle; either from the earth at first fluid has been afterwards hardened by the actions of the sun, at least towards the last strata which compose it? Or that the almighty has created it instantaneously in the state where physical causes would have brought it." It appears to me that the author would have done better to hold himself firmly to this last cause, which dispenses from all researches and speculations, only to give an explanation which

which not only ſins in the principle, but in almoſt all the points of conſequence, which might be drawn from it.

For is there any thing more independent one of the other than the heat which properly belongs to the earth, and that which comes to it externally? It is natural, it is reaſonable even to imagine, that there really exiſts in nature a law of calculation, by which the emanations of this internal heat of the globe, would exactly follow the inverted ratio the acceſſions of the heat of the ſun on the earth? And in ſo preciſe a proportion that the augmentation of the one would exactly compenſate the diminution of the reſt. A little reflection is only requiſite to convince us that this relation purely ideal is unfounded, and that conſequently the real fact of the equality of the ſummers, or of the equal intenſity of heat in ſummer, in all climates, is not derived from that precarious combination, of which this phyſician makes a principle, but from a quite different cauſe, which we are going to explain.

Why in all climates of the earth, where obſervations have been made with comparable thermometers, is it found that the ſummers (that is to ſay, the intenſity of heat in ſummer) are equal; while the winters (that is ſay, the intenſity of heat in winter) are prodigiouſly different, and ſo much the more unequal as we advance nearer the frigid zones? This then is the queſtion, the fact is true, but the explanation of it given by the able phyſician above quoted, appears to me to be erroneous, it returns us directly to final cauſes which he thought to avoid, for it is not telling us, for every explanation that the ſun and the earth were at firſt in ſuch a ſtate that the heat of one might ſcorch the external ſtrata of the other, and harden them to ſuch a degree that the emanations of the terreſtrial heat would

would always find obſtacles againſt their going out, which might be exactly in proportion of the facility with which the heat of the ſun arrives to each climate; and that from this admirable contexture of the ſtrata of the earth, which more or leſs permits the iſſue of the emanations of the central fire, there reſults on the ſurface of the earth an exact compenſation of the ſolar and terreſtrial heat, which nevertheleſs renders the winters every where alike, as well as the ſummers: but which in reality, as there are only equal ſummers in all climates, and that the winters on the contrary are very unequal; it neceſſarily muſt enſue that theſe obſtacles ſet to the liberty of the central emanations, are ſtill greater than they are ſuppoſed to be, and in fact, in the proportion which the inequality of the winters of different climates exact? Now who is there but ſees that theſe ſlight combinations are not in the plan of the ſovereign creator, but only engendered in the head of a phyſician, who not being able to explain the equality of ſummers, and this inequality of winter, has had recourſe to two ſuppoſitions, which have no foundation, and to combinations which even in his eyes can have no other merit than that of being accommodated to his theory and to recall, as he himſelf terms it, that *ſurprizing* equality of ſummers to an *intelligible principle*? But this principle once underſtood is only a combination of two ſuppoſitions, which are both of the order of thoſe which render the impoſſible, *poſſible*, and hence in fact would repreſent the abſurd as intelligible.

All phyſicians employed on this point, agree with me that the terreſtrial globe poſſeſſes of itſelf a heat, independent of that which comes from the ſun; is it not evident that this innate heat ſhould be equal

equal on all points on the ſurface of the globe, and that there might be no other difference in this reſpect than that which muſt reſult from the ſwelling of the earth at the equator, and of its flatneſs under the poles? A difference which being in the ſame ratio nearly as the two diameters, does not exceed $\frac{1}{230}$ ſo that the innate heat of the terreſtrial ſpheriod muſt be $\frac{1}{230}$ times greater under the equator than under the poles. The deperdition which is made and the time of refrigeration muſt therefore have been quicker or more ſudden in the northern climates, where the thickneſs of the globe is not ſo great as in the ſouthern climates, but this difference of $\frac{1}{230}$ cannot produce that of the inequality of the central emanations, whoſe relation to the heat of the ſun in winter being : : 50 : 1 in the adjacent climates to the equator is found already double to the 27th degree, triple to the 35th, quadruple to the 40th, tenfold to the 49th, and 35 times greater to the 60th degree of latitude. This cauſe which preſents itſelf, contributes to the cold of the northern climates, but it is inſufficient for the effect of the inequality of the winters, ſince this effect would be 35 times greater than its cauſe to the 60th degree, and greater ſtill, and even exceſſive in climates nearer the poles, and that at the ſame time it would in no part be proportional to this ſame cauſe.

On the other hand, it is without any foundation, when we attempt to maintain that in a globe which has received, or which poſſeſſes a certain degree of heat, there might be ſome parts therein much colder than others. We are ſufficiently acquainted with the progreſs of heat, and the phenomena of its communication to be aſſured that it is every where diſtributed alike, ſince by applying a body, that is even

even cold, on a hot body, it will consequently communicate to the other sufficient heat for both to be of the same degree of temperature in a short time. It must not therefore be supposed that towards the poles there are strata of colder matters, less permeable to the heat than in other climates; for, of whatsoever nature they may be supposed to be, experience shews us that in a very short time they would become as hot as the rest.

The great cold in the north does not therefore proceed from these pretended obstacles which might oppose themselves to the issue of heat, nor from the slight difference which that of the diameters of the terrestrial spheriod must produce; and it has appeared to me, after having reflected thereon, that we ought to attribute the equality of the summer, and the great inequality of the winters to a much more simple cause, which nevertheless has escaped all philosophers.

It is certain that, as the innate heat of the earth is much greater than that which comes from the sun, the summers should appear every where nearly alike, because this heat of the sun, forms only a small augmentation to the real fund of innate heat, and that consequently this heat emitted from the sun is no more than $\frac{1}{50}$ of the innate heat of the globe, the longer or shorter stay of it on the horizon, its greater or less obliquity on the climate, and even its total abscence would only produce $\frac{1}{5}$th difference on the temperature of the climate, and hence the summers must appear, and are in fact nearly equal in all the climates of the earth. But what makes the winters so very unequal, is that the emanations of this internal heat of the globe is found in a very great measure suppressed as soon as the cold and frost binds and consolidates

the ſurface of the earth and waters. This heat which iſſues from the globe, decreaſes in the air in proportion, and in the ſame ratio as the ſpace increaſes, and the ſole condenſation of the air by this cauſe is ſufficient to produce cold winds, which acting againſt the ſurface of the earth, binds and freezes it. As long as this confinement of the external ſtrata of the earth remains, the emanations of the internal heat are retained, and the cold appears to be, nay in fact is, very conſiderably increaſed by this ſuppreſſion of a part of this heat; but as ſoon as the air becomes milder and the ſuperficial ſtrata of the globe loſes its rigidity, the heat retained all the time of the froſt, iſſues out in greater abundance than in climates where it does not freeze at all; ſo that the ſum of the emanations of the heat becomes equal and every where alike: and this is the reaſon that plants vegetate quicker, and the harveſt is reaped in much leſs time in northern countries, and for the ſame reaſon it is, that often at the beginning of ſummer we feel inſupportable heat, &c.

Should we doubt of the ſuppreſſion of the emanations of the internal heat by the effect of froſt, we need only to be convinced thereof, recollect to circumſtances univerſally known. That after a froſt, ſnow, which we may perceive to thaw in pits, aqueducts, ciſterns, quarries, ſubterraneous vaults or mines, when even theſe depths, theſe pits or ciſterns contain no water. The emanations of the earth having their free iſſue through theſe kinds of vents, the ground which covers the top is never frozen ſo ſtrong as the open land; to the emanations it permits their general courſe, and their heat is ſufficient to melt the ſnow, eſpecially in hollow places, whereas it ſubſiſts and remains on all the

reſt

reſt of the ſurface where the earth is not excavated.

This ſuppreſſion of the emanations of the innate heat of the earth, is not only made by the froſt, but likewiſe by the ſimple binding of the earth, often occaſioned by a leſs degree of cold than that which is neceſſary to freeze the ſurface; there are very few countries where it freezes in the plains beyond the 35th degree latitude, particularly in the northern hemiſphere: it appears therefore that from the equator, as far as the 35th degree, the emanations of the terreſtrial heat having always their free iſſue, there ought to be in that part almoſt no difference between winter and ſummer, ſince this difference might proceed only from two cauſes, both too ſlight to produce any ſenſible effect. The firſt of theſe cauſes is, the difference of the ſolar action, but as this action is itſelf much ſmaller than that of the terreſtrial heat, their difference becomes ſo inconſiderable, that it may be regarded as nul: the ſecond cauſe is, the thickneſs of the globe, which towards the 35th degree, is near $\frac{1}{500}$th part leſs than at the equator but this difference can ſtill only produce a very ſlight effect, no ways proportional to which obſervations indicate, ſince at 35 degrees the relation of the emanations of the terreſtrial heat to the ſolar heat, is in ſummer from 33 to 1 and in winter from 153 to 1 which gives 186 to 2 or 93 to 1. It therefore can be only owing to the conſolidation of the earth, occaſioned by the cold or even to the cold produced by the durable rains which fall in theſe climates that we can attribute this difference between winter and ſummer, the binding of the earth by cold, ſuppreſſes a part of the emanations of the internal heat, and the cold always renewed by the fall of rain, diminiſhes the in-

intensity of this same heat; these two causes therefore together produce the difference between winter and summer.

After this exposition, it appears to me that we are now in a state of understanding why the winters seems to be so different. This point of general physics had never been discussed: no person before M. de Mairan had even sought for the means of explaining it, and we have precedently demonstrated the insufficiency of the explication he gives thereon; mine on the contrary, appears to me so simple and so well founded, that I do not doubt but that it will be understood by men of good and clear judgment.

After having proved that the heat which comes to us from the sun is greatly inferior to the innate of our globe; after having explained, that by supposing it only $\frac{1}{50}$ part, the refrigeration of the globe to actual temperature, cannot be made but in 75832 years; after having demonstrated that the time of this refrigeration should still be longer, if the heat sent from the sun to the earth was in a greater relation, that is to say of $\frac{1}{25}$ or $\frac{1}{10}$ instead of $\frac{1}{50}$, we cannot be blamed for having adopted the proportion which appeared to us the most plausible by physical reasonings, and at the same time the most suitable, not to extend too far back the time of the commencement of nature, which we have fixed at 37 or 38000 years, dating it from the first day.

I nevertheless acknowledge, that this time, all considerable as it is, does not appear sufficiently long for certain changes, certain successive alterations which Natural History demonstrates to us, and which seems to have required a course of centuries still

ſtill longer: I ſhould therefore be greatly inclined to imagine, that, in reality, the time before indicated for the duration of nature, ſhould be increaſed perhaps double, if we are at leiſure for the explanation of every phenomena. But I repeat, I am confined to the leaſt terms, and I have reſtrained the limits of time as much as was poſſible to be done without contradicting facts and experiments.

My theory perhaps may be chicanely attacked by another objection, which is right to be guarded againſt. It will be told me, that I have ſuppoſed after Newton, the heat of boiling water three times greater than that of the ſun in ſummer, and iron heated red hot eight times greater then boiling water, that is to ſay, 24 or 25 times greater than that of the actual temperature of the earth, and that there is ſomething hypothetical in this ſuppoſition, on which I have founded the ſecond baſis of my calculations, whoſe reſults would be without doubt very different if this red heat of iron or glaſs in incandeſcence, inſtead of being in fact 25 times greater than the actual heat of the globe, was for example only 5 or 6 times as great.

The better to know the value of this objection let us directly make a calculation of the refrigeration of the earth, in the ſuppoſition that in the time of incandeſence it was only five times hotter than it is at preſent, by ſuppoſing as in other calculations it is only $\frac{1}{50}$th of the terreſtrial heat; this ſolar heat which now makes a compenſation of $\frac{1}{50}$ only made the compenſation of $\frac{1}{250}$ in the time of incandeſcencence, theſe two terms added together gives $\frac{6}{250}$ which multiplied by $2\frac{1}{2}$, the half of the ſum of all the terms of the diminution of heat, gives $\frac{15}{250}$ for

for the total compensation which the heat of the sun has made during the whole period of the deperdition of the innate heat of the globe, which is 74047 years; therefore we shall have : $\frac{16}{25}$: : 74047 : 888 $\frac{14}{25}$ from which we see that the prolongation of refrigeration, which for a heat 28 times greater than actual temperature, has been only 770 years, should have been 888 $\frac{14}{25}$. In the supposition that this first heat should have been only five times greater than this actual temperature; this alone shews us that if even we would suppose this primitive heat greatly below 25, there would be only a longer prolongation of the refrigeration of the globe, and that alone appears to me sufficient to satisfy the objection.

In short, will it be said, you have calculated the duration of the refrigeration of the planets, not only by the inverted ratio of their diameters, but also by the inverted ratio of their density; this might be well founded if we could imagine that in fact there exists matters whose density is as different from that of our globe; but does it exist? What for example, will be the the matter of which Saturn is composed, since its density is more than five times less than that of the earth?

To this I answer, that it would be very easy to find in the vegetable class, matters 5 or 6 times less dense than a mass of iron, marble, hard calcareous stone, &c. of which we know that earth is the principal composition, but without quitting the mineral kingdom, and considering the density of these five matters we have 21 $\frac{10}{72}$ for iron, 8 $\frac{25}{72}$ for white marble, for gres, 7 $\frac{21}{72}$ for common marble and calcareous stone 7 $\frac{20}{72}$ taking the mean term of the densities of these five matters of which the terrestrial globe is principally composed we find its den-

density to be 10 $\frac{5}{18}$. It is therefore required to find a matter whose density is 1 $\frac{189\frac{1}{9}}{1000}$ which is the which is the same relation of 189 density of Saturn to 1000 density of the earth. Now this matter might be a kind of pumice stone, a little denser than common pumice stone, whose relative density is here 1 $\frac{69}{72}$; it appears therefore that Saturn is principally composed of a light matter similar to pumice stone.

So likewise the density of the earth being to that of Jupiter : : 1000 : 292, or : : 10 $\frac{5}{81}$: 3 $\frac{179}{1000}$ we must think that Jupiter is composed of a denser matter than pumice stone but much less dense than chalk.

The density of the earth being to that of the moon : : 1000 : 702, or : : 10 $\frac{5}{18}$: 7 $\frac{215}{1000}$ this secondary planet is composed of a matter whose density is not quite so great as that of hard calcareous stone, but greater than that of soft calcareous stone.

The density of the earth being to that of Mars : : 1000 : 730, or : : 10 $\frac{5}{18}$: 13 $\frac{602\frac{1}{9}}{1000}$ it must be thought that this planet is composed of a matter whose density is little greater than that of gres, and not so great as that of white marble.

But the density of the earth being to that of Venus : : 1000 : 12700, or : : 10 $\frac{5}{18}$: 13 $\frac{520\frac{7}{9}}{1000}$ it may be supposed that this planet is chiefly composed of a denser matter than emery and less dense than zink.

In short, the density of the earth being to that of

of Mercury :: 1000 : 2040, or :: $10\frac{5}{18}$: $20\frac{966\frac{2}{3}}{1000}$ it muſt be thought that this planet is compoſed of a matrer leſs denſe than iron, bnt more ſo than tin.

How, will it be ſaid, can, animated nature which you ſuppoſe every where eſtabliſhed, exiſt in planets of iron, emery or pumice ſtone? By the ſame cauſes, I ſhall anſwer, and by the ſame means as it exiſts on the terreſtrial globle, although compoſed of ſtone, gres, marble, iron and glaſs. There are other planets like our globe, the principal is one of the matters we have juſt indicated, but the external cauſes will ſoon have altered the ſuperficial ſtrata of this matter, and according to the different degrees of heat or cold, dryneſs or humidity, they will have converted this matter in a very ſhort time, of whatſoever nature we may ſuppoſe it to be, in a fertile earth proper to receive the ſeeds of organized nature, which all only need of heat and moiſture to develape itſelf.

After having ſatisfied the objections which appeared to preſent themſelves the firſt, it is neceſſary to explain the facts and obſervations by which we are aſſured that the ſun is only an acceſſary, a ſmall complement to the real heat which continually emanates from the globe of the earth; and it will be juſt at the ſame time to ſee how comparable thermometers have taught us in a certain manner that the heat in ſummer is equal in all the climates of the earth, excepting ſome places, as Senegal, and ſome other parts of Africa, where the heat is greater than elſeweere, for particular reaſons of which we ſhall ſpeak when it is requiſite to examine the exceptions to this general rule.

It may be demonſtrated by inconteſtible valuations, that light and conſequently the heat of the ſun

ſun emitted on the earth is very great in compariſon of the heat emitted by the ſame body in winter, and that nevertheleſs, by very exact and reiterated obſervations, the difference of the real heat of ſummer is very ſmall. This alone would be ſufficient to prove that a very great heat in the terreſtrial globe of which that of the ſun makes only the complement; for by receiving the rays of the ſun on the ſame thermometer in ſummer and in winter, Mr. Amontons was the firſt who obſerved, that the greateſt heat in ſummer in our climate differs from the cold in winter, when the water congeals as only 7 differs from 6, whereas it can be demonſtrated that the action of the ſun in ſummer is about 66 times greater than that of the ſun in winter; it therefore cannot be doubted, that there is a fund of very great heat in the terreſtrial globe, on which as a baſe, the degrees of heat ariſe which comes to us from the ſun, and that the heat at the ſurface of the globe does not give us a much greater quantity of heat than that which comes to us from the ſun.

If it be aſked how we can aſſert that the heat emitted by the ſun in ſummer is 66 times greater than the heat ſent by the ſame body in winter in our climate: I cannot better anſwer this than by referring to the memoirs given by the late M. de Mairan in 1719, 1722, and 1765, and inſerted in thoſe of the Academy, in which he examined with a ſcrupulous attention the viciſſitudes of ſummers in different climates. Theſe cauſes may be reduced to four principal ones: viz. 1. The inclination under which the light of the ſun falls according to the different height of the ſun on the horizon; 2dly. The greater or leſs intenſity of light in proportion as its paſſage in the atmoſphere is more or leſs oblique; 3dly. The different diſtance

of the earth to the ſun in ſummer and winter; 4th The inequalities of the length of days in different climates. And by departing from the principal that heat is proportional to the action of light, it will be eaſily demonſtrated, that theſe four united cauſes, combined and compared, diminiſhes with reſpect to our climate this action of the ſun's heat in a ratio of about 66 to 1 between the ſummer and the winter ſoltice. And by ſuppoſing the weakneſs of the action of light by theſe four cauſes, that is to ſay, 1. By the leaſt aſcenſion or elevation of ſun at noon in the winter ſoltice, in compariſon of its aſcenſion at noon in the ſummer ſoltice; 2dly. By the dimunition of the light, which more obliquely traverſes the atmoſphere in the winter ſoltice than in the ſummer ſoltice; 3dly. By the greateſt proximity of the earth to the ſun in winter than in ſummer; 4thly. By the dimunition of the continuity of the heat produced by the ſhorteſt day, or by the largeſt abſence of the ſun in the winter ſoltice, which in our climate is nearly double that of the ſummer ſoltice: it will not be doubted that the difference is in fact very great, and about 66 to 1 in our climate, and this true theory may be regarded as certain, as the ſecond truth from experience, and which demonſtrates to us by the obſervations of the thermometer immediately expoſed to the ſun's rays in winter and ſummer, that the difference of real heat in theſe two is nevertheleſs at moſt only from 7 to 6; I ſay at moſt, for this determination given by Mr. Amontons is not by far ſo exact as that which has been made by M. de Mairan, after a great number of ulterior obſervations, by which he proves that this relation is :: 32 : 31. What therefore muſt indicate this prodigious inequality between theſe two relations of the action of the

the solar heat in summer and in winter, which is from 66 to 1: and of that of the real heat, which is only from 32 to 31 between summer and winter? Is it not evident that the innate heat of the globe of the earth, is a number of times greater than that which comes to us from the sun? It appears in fact, that in the climate of Paris this heat of the earth is 29 times greater in summer, and 491 times greater in winter than that of the sun, as M. de Mairan has determined it. But I have already said that we must not conclude from these two combined relations, the real relation of the heat of the globe of the earth, to that which comes to us from the sun, and I have given reasons which have determined me to suppose that we may estimate this heat of the sun 50 times less than the heat which emanates from the earth.

It now remains for us to render an account of the observations made by thermometers, from the year 1701 to 1756 inclusive, we have collected the greatest degree or heat, and that of the greatest cold which has been at Paris each year; we have made a total of these and found that the mean year in all the thermometers reduced to Reaumurs division, have given 1026, for the greatest heat in summer, that is to say, 26 degrees above the freezing point. We have likewise found, that the common degree of the greatest cold in winter has been, within these 56 years 994 or 6 degrees below the freezing point of water. from whence it has been reasonably concluded, that the greatest heat in our summers at Paris differs from the greatest cold of our winters only $\frac{1}{32}$ since 994 : 1026 : : 31 : 32. It is on this foundation that we have said that the relation of the greatest heat to the greatest cold was no more than : : 32 : 31. But it may be objected against

against the precision of this valuation, the defect of the construction of the thermometer, and Reaumurs's division, to which we have here reduced the scale of all the rest, and this defect is extended only 1000 degrees below that of ice, as if this thousand degrees was in fact that of absolute cold, whereas absolute cold does not exist in nature, and that of the smallest heat, should be supposed 10,000 instead of 1000, which would alter the thermometers gradation. It may likewise be said that in fact it is not impossible that all our sensations between the greatest heat and the greatest cold, is comprized in as small an interval as that of unity on thirty-two of heat, but that the voice of judgment seems to be raised against this opinion, and tells us, that this limit is too confined, and that it is much easier to reduce this interval than to give it an eighth or a seventh instead of a thirty-second.

But be this valuation as it may, which will perhaps be found still stronger when we shall have thermometers better constructed; it cannot be doubted but that the heat of the earth, which serves for a base to the real heat we feel, is not very considerably greater than that which comes to us from the sun, and that this last is only a small complement thereof. So likewise, although the thermometers which we have used err from the principle of their construction, and from some other defects in their gradation, we cannot doubt of the truth of these facts which have been shewn us by observations made in different countries with these same thermometers, constructed and gradated in the same manner, because relative truths and comparative results are only made use of here, and not absolute truths.

Now in the same manner as we have found, from the observation of 56 successive years, the heat of sum-

ſummer at Paris, 1026 or 26 degrees above the freezing point, we have alſo found with the ſame thermometers, that this heat in ſummer, was 1026 in every climate of the earth from the equator to the polar circle;* at Madagaſcar, in the iſlands of France and Bourbon, Roderigo, Siam, and the Eaſt Indies; at Algiers, Malta, Cadiz, Montpelier, Lyons, Amſterdam, Upſal, Peterſburgh, and as far as Lapland near the polar circle. At Cayen, Peru, Martinico, Carthagena in America, at Panama, in ſhort in all the climates of the two hemiſpheres and continents where obſervations could be made, it has been conſtantly found that the liquor of the thermometer roſe equally to 25, 26, or 27 degrees in the hotteſt days in ſummer: and from hence enſues the inconteſtible fact of the equality of heat in ſummer in all climates of the earth. There is on this ſubject other exceptions beſides that of Senegal, and ſome other places where the thermometer riſes 5 or 6 degrees higher, that is to ſay, to 31 or 32 degrees; but it is from accidental and local cauſes, which do not alter the truth of the obſervations nor the certainty of this general fact, which alone might likewiſe demonſtrate to us, that there really exiſts a very great heat in the terreſtrial globe; the effect or the emanations of which are nearly equal in all the points of its ſurface, and that the ſun very far from being the only ſphere of heat which animates nature, is at beſt only the regulator.

This important fact, which we conſign to poſterity, will diſcover to it the real proportion of

* On this ſubject conſult the Memoirs of the late M. de Reaumur, in thoſe of the Academy of the years 1735 and 1742, and alſo the Memoirs of the late M. de Mairan, in thoſe of the year 1765, p. 213.

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the dimunition of the heat of the terreſtrial globe, which, we have been only able to determine in a hypothetical manner : in a few centuries, we ſhall ſee that the greateſt heat of ſummer, inſtead of raiſing the liquor of the thermometer to 26, will not raiſe it more than to 25, or 24, or lower, and we ſhall judge by this effect, which is the reſult of all the combined cauſes, of the value of each of the particular cauſes, which the total effect of heat produces to the ſurface of the globe; for independent of the heat which belong to the earth and which it poſſeſſed from the time of incandeſcence, a heat the quantity of which is very conſiderably diminiſhed, and will continue to diminiſh in courſe of time, independent of the heat which comes to us from the ſun, which may be looked upon as conſtant and which conſequently in futurity will make a greater compenſation than at preſent : to the loſs of this innate heat of the globe, there are two other particular cauſes, which may add a conſiderable quantity of heat to the effect of the two firſt, which are the only ones which we have till now made the valuation of.

One of the particular cauſes proceeds in ſome meaſure from the firſt general cauſe, and may add ſomething thereto. It is certain that during the time of incandeſcence, and in all the ſubſequent ages, till that of the refrigeration of the earth, all volatile matters could not reſide at the ſurface, nor even in the internal part of the globe ; they were raiſed and diſperſed in the form of vapours, and have not been able to depoſit themſelves but ſucceſſively in proportion as it cooled, theſe matters have penetrated through the clefts and crevices of the earth to great depths, in an infinity of places : this then is the primitive foundation of volcanos, which as is well known, are all found in

in lofty mountains, where the clefts of the earth are ſo much the greater as theſe points of the globe are more projecting and iſolated. This depoſit of the volatile combuſtible matters of the firſt age will have been prodigiouſly augmented by the addition of every combuſtible matter, whoſe formation is from ſubſequent ages. Pyrites, ſulphurs, coal, bitumen, &c. have penetrated into the principal cavities of the earth, and produced almoſt every where great maſſes of inflammable matters, and often conflagrations which manifeſt themſelves by earthquakes, eruptions of volcanos, and by the hot ſprings which flow from mountains, or run internally in the cavities of the earth. It may therefore be preſumed that theſe ſubterraneous fires, ſome of which burn without exploſion, and others with great noiſe and violence, ſomewhat increaſe the general heat of the globe. Nevertheleſs this addition of heat can be only very ſlight, for it has been obſerved that it is nearly as cold on the top of volcanos, as on the top of other mountains of the ſame height, excepting at the time when the volcano throws out inflamed vapours or burning matters; this particular cauſe of heat appears to me therefore not to merit ſo much conſideration as ſome phyſicians have given to it.

It is not the ſame with reſpect to a ſecond cauſe, which it ſeems has not been thought of, which is the motion of the moon round the earth. This ſecondary planet performs its revolution round us in 27 days and one third, and being 85 thouſand 325 leagues diſtant, it goes over a circumference of 436 thouſand 329 leagues in this ſpace of time, which makes a motion of 817 leagues in an hour, or from 13 to 14 leagues a minute: although this rout is perhaps the ſloweſt of all

all the celeſtial bodies, yet it is rapid enough to produce on the earth which ſerves for axis or pivot to this motion, a conſiderable heat from the friction which reſults from the weight and velocity of this planet. But it is not poſſible to value this quantity of heat produced by this exterior cauſe, becauſe hitherto we have had nothing which might ſerve us for unity or term of compariſon. But if we ever attain to diſcover the number, magnitude, and velocity of all the planets which circulate round the ſun, we ſhall then be able to judge of the quantity of heat which the moon can give to the earth, by the much greater quantity of fire which all theſe vaſt bodies excite in the ſun. And I ſhould be greatly inclined to think that the heat produced by this cauſe in the globe of the earth, does not prevent it from making a very conſiderable part of its own heat; and that in conſequence we muſt ſtill extend the limits of time for the duration of nature. But let us return to our principal object.

We have obſerved that the ſummers are very nearly equal in all the climates of the earth, and that this truth is founded on inconteſtible facts; but it is not the ſame with reſpect to winters, they are very unequal in different climates, as we remove farther from that of the equator, where the heat in winter and ſummer is nearly the ſame. I think I have given the reaſon in the courſe of this memoir, and have explained in a ſatisfactory manner the cauſe of the inequality by the ſuppreſſion of the terreſtrial heat. This ſuppreſſion is, as I have ſaid, occaſioned by the cold winds which fall from the air, bind the earth, freeze the waters, and ſhut up the emanations of the terreſtrial heat during the time the froſts remains: ſo that it is not all ſurpriſing that the cold in winter is in fact

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ſo much the greater as we advance further towards the climates, where the maſs of air receiving the rays of the ſun more obliquely, is for that reaſon colder.

But with reſpect to the cold as well as the heat, there are ſome countries which are an exception to the general rule. At Senegal, Guinea, Angola, and probably in every country where the natives are black, as in Nubia, the country of the Papous, New Guinea, &c. it is certain that the heat is greater there than in any other part of the earth; but it is from local cauſes, which we have given the explanation of in this work. Therefore in theſe particular climates, where the eaſt wind reigns during the whole year, and paſſes over a very conſiderable tract of land, where it receives a ſcorching heat, before it arrives there, it is no ways ſurprizing that the heat is found 5, 6, and even 7 degrees greater than it is elſewhere. And ſo likewiſe the exceſſive colds of Siberia proves the ſame, excepting that this part of the ſurface of the globe is much higher than all the adjacent parts. "The "northern Aſiatic countries (ſays the Baron Strahlenberg in his deſcription of the Ruſſian Empire) "are conſiderably more elevated, than the Europeans. They are like a table in compariſon "of the bed on which it is placed; for ſince, "coming from the weſt and leaving Ruſſia, we "paſs to the eaſt by the mountains Riphea and "Rymnikas to enter Siberia, we always advance "more on an aſcent than in a deſcent." "There "are many places in Siberia, (ſays M. Gmelin) "which are not leſs elevated above the reſt of the "earth, nor leſs remote from its center, than "many high mountains in many other regions "are." Theſe plains of Siberia, appear in fact, to be as high as the ſummit of the Riphean

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mountains, on which the ice and ſnow do not wholly melt during ſummer: and if this ſame effect does not happen in the plains of Siberia, it is becauſe they are leſs iſolated, for this local circumſtance alſo adds much to the duration and to the intenſity of cold and heat. A vaſt plain once made hot will retain its heat longer than an iſolated mountain, although both are alike elevated; and for this ſame reaſon the mountain once cooled will retain its ſnow or ice longer than the plain.

But if we compare the exceſs of heat to the exceſs of cold, produced by theſe particular and local cauſes, we ſhall perhaps be ſurprized to ſee, that in ſuch countries as Senegal, where the heat is greater, it nevertheleſs exceeds ſeven degrees the greateſt general heat, which is 26 degrees above the freezing point and as the greateſt height to which the liquor in the thermometer riſes is at moſt only 33 degrees above this point, whereas the great colds of Siberia ſometimes reach as far as 60 or 70 degrees below this ſame freezing point: and that at Peterſburgh, Upſal, &c. under the ſame latitude of Siberia, the greateſt cold does not make the liquor deſcend more than to 25 or 26 degrees below the freezing point: therefore, the exceſs of the heat produced by the local canſes being only 6 or 7 degrees above the greateſt heat of the reſt of the torrid zone, and the exceſs of the cold produced likewiſe by local cauſes, being more than 40 degrees below the greateſt cold, under the ſame latitude, we muſt conclude, that theſe ſame local cauſes have much more influence in cold climates than in hot. Although we do not at firſt ſee what this great difference in the exceſs of cold and heat may produce: nevertheleſs, by reflecting thereon it appears to me, that we may eaſily conceive the reaſon of this difference,

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the augmentation of the heat of ſuch a climate as Senegal, can only proceed from the action of the air, the nature of the ſoil, and the depreſſion of the ground : this country almoſt on a level with the ſea, is in a great meaſure covered with ſcorching ſands, and an eaſt wind continually blows there, which inſtead of refreſhing the air, only renders it burning, becauſ this wind traverſes, before it arrives there more than 2000 leagues of land, over which it gets hotter and hotter as it paſſes : and nevertheleſs all theſe united cauſes produce only an exceſs of 6 or 7 degrees above 26, which is the term of the greateſt heat of all the other climates. But in ſuch a country as Siberia, where the plains are elevated like the ſummits of mountains above the level of the reſt of the earth, this ſole difference of elevation muſt produce an effect proportionally much greater than the depreſſion of the ground of Senegal, which cannot be ſuppoſed greater than that of the level of the ſea ; for if the plains of Siberia are only elevated 4 or 500 fathom above the level of Upſal or Peterſburgh, we muſt ceaſe from being aſtoniſhed that the exceſs of cold is ſo great there ; ſince the heat, which emanates from the earth, decreaſes at each point as the ſpace increaſes, this cauſe alone of the elevation of the ground ſuffices to explain this great difference of cold under the ſame latitude.

On this point there remains only one intereſting queſtion, men, animals and plants, may for ſome time ſupport, the rigour of this extreme cold, which is 60 degrees below the freezing point ; but could they alike ſupport a heat which ſhould be 60 degrees above it ? Yes, if we could take the precaution of ſheltering ourſelves from the heat, as we know how to do againſt the cold, only for a ſhort time ; and if the air could, during the re-

mainder of the year, refresh the earth, in the same manner as the emanation of the heat of the globe warms the air in cold countries; we know of plants, insects and fishes, which grow and live in hot baths, whose heat is 45, 50 and even 60 degrees. There are therefore species in living nature, which can support this degree of heat; and as the negroes are in the human race, those whom a strong heat the least incommodes, should we not conclude therefore, with sufficient probability, that, in our hypothesis, their race are more ancient than that of the white people?

F I N I S.

THE

CONTENTS.

CONTENTS.

VOLUME the FIRST.

OF the Nature of Man - - - page 1
Of Infancy - - - - - - - - 13
Of Puberty - - - - - - 36
Description of Man - - - - - 63
Of old age and Death - - - 83
Tables of the Mortality of the Human Species 100
Of the Sense of seeing - - - 138
Of the Sense of hearing - - 149
Of the Senses in general - - 157
Of the Varieties in the Human Species - 171
Of the Nature of Animals - - - 293
Of Homoduplex - - - - 345
Of the Horse - - - - - 371
Of the Ass - - - - - 425
Of

Of the Ox - - - - - - 444
Of Sheep - - - - - - 469

VOLUME the SECOND.

OF Sheep - - - - - page 1
History of Swine, the Hog of Siam, and the Wild Boar - - - - 24
History of the Dog - - - - 39
—— Cat - - - - 69
Fallow Deer - - - 114
Hare - - - - 131
Carnivorous Animals - 149
Fox - - - - 189
Badger - - - 196
Otter - - - 200
Fouine - - - 203
Polecat - - - 209
Ferret - - - 211
Weazel - - - 215
Ermine or Stoat - - 218
Squirrel - - - 219
Rat - - - - 225
Mouse - - - 227
Mulot, or Field Mouse - 229
Water Rat - - - 233
Campagnol, or little Field Rat 235
Guinea Pig - - 236

History

History of the Shrew Mouſe - - 241
Water Mouſe - - 243
Mole - - - 246
Bat - - - - 247
Loir, or Great Dormouſe - - 253
Lerot, or Middle Dormouſe - 259
Muſcardine, or Small Dormouſe 260
Surmulot - - - 261
Marmot - - - 264
Bear - - - - 270
Beaver - - - 280
Racoon - - - 299
Coati - - - 301
Agouti - - - 304
Lion - - - - 307
Tigers - - - 324
Animals of the Old Continent - - 328
New World - - 347
common to both - - 358
Of the Tiger - - - - 381
Panther, Ounce and Leopard - 390
Jaguar - - - - - - 406
Couguar - - - - - 407
Lynx, or Lupus Cervarius - 410
Caracal, or Syagua - - 418
Hyæna - - - - 420
Civet, or Zibet - - - - 429
Genet - - - - - 439
Black Wolf - - - - - 440
Ondatra, or Deſmun - - 442

VOLUME the THIRD.

Of the Pecary, or Tacajeu - - 1
Rouſſette, Rougette, or Vampyre - 9
Polatouch - - - - 15
Little Grey Squirrel - - 18
Palmiſt, or Squirrel of Barbary and Switzerland - - - - 21
Tamanoir, Tamandua, Fourmiller, or Ant-eater - - - 23
Tatous, Tattes, called Armadillo by the Spaniards - - - 33
Apai, or Tatow with 3 Streaks - 37
Encoubert, or Tatow with 6 Streaks 40
Tatuetti, or Tatow with 8 Streaks 41
Cachicame, or ditto with 9 ditto - 42
Kabaſſou, or ditto with 12 ditto - 43
Cinquincon, or ditto with 18 ditto - 44
Paca, Sarigue, or Opoſſum - 52
Marmoſe - - - - 67
Gayopollin - - - - 68
Elephant - - - - - 69
Camel and Dromedary - - 122
Buffalo, Bonaſus, Aurocks, Biſon and Zebra - - - - - 134
Zebu - - - - - 159
Mufflon and other Sheep - 159
Axis - - - - - - 161
Tapir, or Anter - - - 173

Of

Of the Zebra - - - - - 175
Hippopotame - - - - 178
Elk, or Rein Deer - - 183
Ibex, Chamois and other Goats - 209
Sariga - - - - - - 228
Gazelles - - - - 229
Bubalous and other Animals which have an affinity with the Gazelle and Goat kind - - - - - 250
Condoma - - - - 253
Guiba - - - - - - 256
Grimmus - - - - 256
Chevrotin - - - - 258
Mazames - - - - 261
Coudous - - - - 265
Musk Animal - - - - 267
Babiroussa - - - - 272
Cabiai - - - - 274
Porcupine - - - - 276
Camelopard - - - 285
Lama and Paca - - - 292
Unan and Ai - - - 301
Surikat - - - - 308
Tarsier - - - - 310
Philanger - - - - 311
Coquallin - - - - 312
Hamster - - - - 313
Mangutia, or Ichneumon - 323
Fossan - - - - - 326
Vansire - - - - 327

Of

Of the Maki - - - - - 328
Loir - - - - - - 332
Lance Bat - - - 333
Serval - - - - 334
Ocelot - - - - 336
Margay - - - - 337
Jackall and Adil - - - 341
Iſatis - - - - - - 346
Glutton - - - - 350
Stinkards - - - - 354
Pecan and Viſon - - - 359
Sable - - - - - 360
Leming - - - - 362
Canadian Otter - - - 366
Seal, Morſe and Manati - - 369
Seal - - - - - 371
Morſe, or Sea Cow - - 384
Dugon - - - - 391
Manati - - - - 393
Nomenclature of Monkies - 403
Orang-Outang, Pongo and Jocko - 433
Pithecos - - - - 450
Gibbon, or Long Armed Ape - 456
Magot - - - - 458
Papion, or Baboon - - 460
Mandril - - - - 464
Wanderow, or Lowando - - 465
Maimon - - - - 467
Macacco and Egret - - 469

Of

Of the Patas - - - - - 471
Malabrouk and Bonet Chinois - 473
Mangabey - - - - - 476
Mona - - - - - 477

VOLUME the FOURTH.

Of the Callitrix, or Green Monkey of St. Jago page 1
Of the Moufta - - - - - - 3
Taloupin - - - - - 45
Sapajou and Sagoin - - 59
Warine and Aloutta - - - 61
Coaitia and Exquima - 65
Sajou - - - - - 70
Sai - - - - - - 71
Saimiri - - - - - 72
Saki - - - - - 74
Tamarin - - - - 75
Wiftiti - - - - - 75
Marikina - - - - 77
Pinch - - - - 78
Mico - - - - - 80
White Bear - - - - 81
Account of feveral Animals not expreſly mentioned in the former part of the Work - 81
Of the Tartarian cow - - - 85
Totai - - 87
Zifel - - - - - 88

Of

Of the Zemni - - - - - 89
Pouch - - - - - 90
Perouafca - - - - 90
Souflik - - - - - 90
Golden Coloured Mole - - 91
White Water Rat - - 92
Guinea Pig - - - - 92
Wild Boar of the Cape of Good Hope 93
Mexican Wolf - - - - 94
Alco - - - - - - - 95
Tayra, or Galera - - - 98
Philander of Surinam - - - 99
Akouchi - - - - 100
Tucan - - - - - 100
Field Moufe of Bafil - - 101
Tapeti - - - - - 104
Comparifon of Animals with Vegetables and other Productions of Nature - 105
Of Re-production in general - - 119
Of Nutrition and Expanfion of Growth - 138
Of the Generation of Animals - - 147
Expofition of the above Syftem - - 165
Experiments on Generation - - 236
Comparifon of my Obfervations with thofe of Lewenhoek - - - - 280
Reflection on the preceeding Experiments 299
Variety in Generation of Animals - - 33[illegible]
Of the Formation of Fœtus - - 351
Of Expanfion or Unfolding and Growth of Fœtus, Delivery &c. - - - 382

Re-

Recapitulation - - - - - 422
Introduction of Minerals - - - 431
On Light, Heat and Fire - - - - 447

VOLUME the FIFTH.

Page
On Light, Heat and Fire, continued - - 1
Of the Elements of Air, Water and Earth 12
Of Minerals, Experimental Part - - - 52
Experiment on the Progreſs of Heat in Bodies 53
Continuation of the Experiments on the Progreſs of Heat in different Mineral Subſtances 71
Of the Relation of different Mineral Subſtances 96
Iron - - - - - - ib.
Emery - - - - - - 97
Copper - - - - - - ib.
Gold - - - - - - ib.
Zinc - - - - - - 98
Silver - - - - - - ib.
Marble White - - - - - 99
Marble Common - - - - ib.
Stone Calcareous hard - - - ib.
Gres - - - - - - 100
Glaſs - - - - - - ib.
Lead - - - - - - ib.

Tin

Tin - - - - - - - ib.
Stone Calcareous ſoft - - - 101
Clay - - - - - - - ib.
Biſmuth - - - - - - - ib.
Porcelain - - - - - - ib.
Antimony - - - - - - ib.
Oker - - - - - - - ib.
Chalk - - - - - - - ib.
Gypſum - - - - - - 102
Wood - - - - - - - ib.
Obſervations on the Nature of Platina - 111
Firſt addition - - - - - 122
Remarks - - - - - - 125
Second Addition - - - - 130
Experiments made by M. de Morteau - ib.
Remarks - - - - - - 137
Experiments on the Tenacity and Decompoſition of Iron - - - - - - - 138
Experiments on the Effects of obſcure Heat 155
Experiments on Light, and on the Heat it can Produce - - - - - - - 173
Invention of burning Mirrors - - - 174
Obſervations made with a View of improving Cannons - - - - - - 208
Experiments on the Strength of Wood - 224
Table of Experiments - - - 254
An eaſy Mode to augment the Solidity, Strength Duration of Wood - - - 261

Ex-

Experiments on the drying Wood in Air, and on its Imbibition in Water - - 275
Experiment, to compare the Time and Gradation of Dryness - - - - 276
Table of the Proportion of Dryness - 279
Table of the Imbibition of Two Pieces of Wood when plunged into Water - - 282
To discover the Difference of the Imbibition of Wood, as the Solidity is greater or less - - - - - - 300
On the Imbibition of Green Wood - 302
On the Imbibition of Dry Wood both in salt fresh Water - - - - 304
Table of these Pieces - - - 305
Theory of the Earth - - - 313
Of the Formation of the Planets - - 355
From the System of Mr. Whiston - - 385
——————— Mr. Burnet - - 394
——————— Mr. Woodward - 396
Exposition of some other System - 400
Geography - - - - - - 411
On the Production of the Strata, or Beds of Earth - - - - - - 429
On Shells and other Marine Productions found in the Bowels of the Earth - - 455

VOLUME the SIXTH.

The Theory of the Earth, continued - 3
On the Inequalities of the Earth - - 10
Of Rivers - - - - - - 28

Proofs of the Theory of the Earth - 58
Of Seas and Lakes - - - - 59
Of the Flux and Reflux - - - 96
Of the Inequalities of the Bottom of the Sea, and of the Currents - - - 105
Of regular Winds - - - - 125
Of irregular Winds, Hurricanes, and ſome other Phænomena cauſed by the Agitation of the Sea and Air - - - 131
Of Volcanos and Earthquakes - - 149
Of New Iſlands, Caverns, and Perpendicular Clefts - - - - - 176
Of the Effect of Rain, Bogs, ſubterraneous Wood, Water, &c. - - - 202
Of the mutations of Land into Sea and Sea into Land - - - - 211
Concluſion - - - - - 236

Supplement - - - - - 1
Obſervations and Experiments for the Improvement of Agriculture - - 3
Of the Cauſe of the Excentricity of the lignous Coats perceived, when the Trunk of a Tree is cut horizontally - - 31
On the Temperature of the Planets - 51

THE

INDEX.

INDEX.

ACRIDOPHAGES, People who feed on Caterpillars——Effect of such bad nutriment —— Vol. I. page 231

Adil, is propabably only the Jackall, of which a domestic race is made, smaller, weaker, and tamer than the wild; for the Adil is with respect to the Jackall, what the Lap Dog is to the Shepherd's Dog —— I. 341 to 346

Admiration of naturalists on the work of insects—— Independent of the enthusiasm for a subject, we constantly admire it so much the more as we observe it more and reason less —— I. 364

Age——Portrait of the moral man in youth and in age.——Age and death —— I. 83

Agouti——its characters and natural habits——its flesh good food, and dressed like that of the Sucking Pig——manner of hunting and taking the

the Agouti——when caught young eafily tamed——he remains at home, and when he quits it, returns of his own accord. The female prepares a bed for her young and produces twice or thrice a year.——The Agouti is an animal particular to America, and not met with in the Old Continent—— fhort defcription of the Agouti —— —— II. 304, 305

Ahu——defcription of the Ahu——The fame animal as the Tzeiran —— — 33

Air.—The attraction of the Moon and Sun caufes the Air a motion of flux and reflux, nearly to that of the flux and reflux of the Sea; —this motion in the Air is very inconfiderable in comparifon of that produced by rarefaction and condenfation.—Contrary currents are remarked in the Air—clouds are feen which move at one time in a contrary direction—this contrariety of motion do not remain long VI. 125

Air.——Defcription of the general properties of Air —— ——

Agouti—Its difference from the Akouchi II. 304

Alce and *Machlis*, mean one and the fame animal —— —— IV. 95, &c.

Alco,—domeftic animal in Peru and Mexico before the arrival of the Europeans.——The word *Alco* appears to be a generical term applied to two or three different kind of animals—— Critical difcuffion on this fubject 95, &c.

Algazel——fpecies of Gazelle found in Arabia—its defcription —— —— III. 229

Aliments—independent of the effect of nutrition, they

they produce another which depends only on their quantity, that is to ſay, on their maſs and volume—Aliments before they ſerve for the nutrition of the body, ſerve it as balance. Their preſence and volume neceſſary to maintain an equilibrium between the internal parts which act and re-act one againſt another.—— When a perſon dies of hunger, it is not ſo much becauſe the body is not nouriſhed, as becauſe it is no longer balanced——the moſt preſſing need is not to refreſh the blood by new chyle, but to maintain the equilibrium of ſtrength in the great parts of the animal machine II. 170, &c.

Alantoid——conſideration of the pretended uſe of the Alantoid in the animal fœtus——phyſical account, by which we may judge of its origin and production —— IV. 290, &c.

Allo Camelus—of which Gerner ſpeaks of, and of which he has given a figure, is a Lama that was brought alive from Peru into Holland III. 122, &c.

Aloutto—a large ſpecies of the Sapajou, (See Warine) —— —— 461

Amble—a pace which ſome horſes naturally have, and which is given to others—explanation of the Horſe in this pace.—Colts often take this pace, eſpecially when they are obliged to go quick, and are not ſtrong enough to trot or gallop —— —— I. 385, &c.

Amber:

Amber. The ſea after violent tempeſts throws Ambergreaſe on the coaſts of Ireland, as it does Succinum, or yellow Amber on thoſe of Pomerania —— VI. 113, &c.

Americans all proceed from one ſtock,—reaſons whereon the author applies this preſumption—*Americans* are a new people—reaſon of this aſſertion—origin of the Americans— their reſemblance to the oriental and northern Tartars —— —— I. 276

America—the natives were not civilized when it was firſt dſicovered —proof of this aſſertion.—The largeſt animal of this new continent, not larger than a ſmall Mule.—Deſcription of the different people of America II. 361, &c.

Amphibious.—The ſole animhls to which we may give this name to in all the rigour of its acceptation, are the Seal, Morſe, and Lunantus, becauſe they are the only ones in which the forames ovale in the heart remains always open, and the only ones which conſequently can live without reſpiring, equally in the air, as in the water — I. 369, &c.

Amſterdam,—State of the ſtrata of the earth there, to 232 feet depth.—The ſoil of Holland has been raiſed 100 feet by the ſedimeut of the Sea —— V. 440, &c.

Analogies living.—The living analogy of the foſſil ſhell called Corn: Amon not known VI.

Anatomy is at preſent only a nomenclatura.—defect of the method by which anatomy is cultitivated — — II. 162

Ancients

Ancients.—Were more inſtructed and advanced than we in the hiſtory of animals, although they did not make uſe of the mode of Nomenclature. ——They had no idea of what we call experience in phyſics——the ancients made the tour of Africa, according to Herodotus—they have neither ſpoken of, or conjectured that the tour of the Globe could be made;——and were far-diſtant from having a juſt meaſure of the circumference of the Globe, although they travelled much —— —— V. 420

Animal——the moſt eſſential parts of, are thoſe by which it takes its food, thoſe which receive and digeſt it, and thoſe by which it renders the ſuperfluous——the animal is the moſt compleat work of nature, and man her maſter-piece,—general idea and deſcription of an animal——its individual is a centerto which all belongs, a point where the whole Univerſe is reflected.—The body of an animal is an internal mold—in which the matter that ſerves for its growth is modelled and aſſimulated to the whole. What muſt be underſtood by the word Animal—— ideas clear and preciſe on this ſubject——there are eſſential and fundamental parts to the body of an animal. The parts of the animal œconomy, which act continually without interruption, are thoſe which have the moſt reſemblance in man, and in an animal—thoſe on the contrary, which the ſenſes and members form reſemblethe leaſt, and the greateſt differences between man and an animal are externally, and principally at the extremities

 of

of the body.—Explanation of the manner in which an animal can be determined to act in such or such a manner by the sole impression of objects on the senses,——in an animal the internal senses differ from the external by the property which the internal sense has of preserving the shocks, and impressions it has received.——Explanation of the manner in which the new born animal is compelled to seek its food——portrait of an animal moved by fear for the first time——in what the perfection of an animal consists — I. 295 to 352

Animals are much more generally dispersed than plants —— the animals and plants which can multiply and re-produce by all their parts, are organized bodies, composed of other similar organical bodies——animals exactly follow the laws of nature—most animals go to copulate only when their growth is entire. Those which have only seminal liquor at that time— -large animals are less prolific than small——reason thereof——small animals eat more in proportion than large——oviparous animals are in general smaller than viviparous——they likewise produce many more——reason thereof—animals which produce but a small number of young, accomplish the greatest part, and even their whole growth, before they are in a state of engendering; whereas animals which multiply fast, engender before their bodies have the half or the fourth of their growth. Animals which can produce their like, although they have not been produced themselves so--in general large,

large animals live longer than ſmall --animals return leſs to the earth than they take from it ——animals hold the firſt rank in nature, becauſe they are capable of more functions than other beings, and have by their ſenſes more relations with objects which ſurround them—with external objects they have relations of the ſame order as ours——in animals there are many parts which grow by a real vegetation ——there are animals which like plants reproduce by the ſame means, the multiplication of the vine fretters, which is made without copulation is ſimilar to that of plants by grains, and that of polypuſſes which is made by cutting, reſembles the multiplication of trees by ſlips—animals in general have much leſs reſemblance than plants——in animals ſome engender a prodigious number of young, and others only produce but one: in plants, on the contrary, produce a very great number — principle by which we may explain all the actions of animals, however complicated they may appear, and without the need of making them agree with thought or reflection —— I. 320

Animals have ſentiment even in a higher degree than we have——they have alſo a conſciouſneſs of their actual exiſtence, but not of their paſt —they have ſenſations but want the faculty of comparing them, that is to ſay, they want the power which produces ideas; for ideas are only compared ſenſations, or to ſpeak clearer, aſſociation of ſenſations — animals being deprived of ideas, and provided with ſenſations

ſations, know not that they exiſt but feel it—they have no knowledge of the paſt, no notion of the future, no idea of time, and conſequently no memory——they cannot diſtinguiſh their dreams from their ſenſations real, and it may be ſaid, that what they dream effectively happen to them——manner of judging of the internal qualities of different animals——the empire of man over animals is a legitimate empire which no revolution can deſtroy—nevertheleſs this empire is not abſolute—it is by the talents of the mind and not by ſtrength and other qualities of matter that man has ſubjugated animals——this empire of man like all other qualities has been founded only from ſociety —— —— I. 320, &c.

Animals.—Firſt deſign on which it appears that all animals have been conceived——in creating them the ſupreme being has employed one idea and varied it at the ſame time in all poſſible manners, in order that man may admire equally the magnificence of the execution and the ſimplicity of the deſign.——The manner in which animals feed and the capacity of their food depends entirely on the capacity of the ſtomach and inteſtines——in almoſt all animals the male becomes more or leſs ferocious, when he couples, and the female when ſhe brings forth——how man has been obliged to act to make himſelf maſter of animals—the original impreſſion of nature is much leſs changed in ſavage than in domeſtic animals——in thoſe which live but a ſhort time, the ſpecies is more ſubject to vary, than

than in thoſe which live a long time——the moſt certain method of judging of the internal nature, and the real ſpecies of animals, is the conformity or difference of their nature and inſtinct ——in animals which produce a great number of young, the young are not ſo perfect at their birth as in thoſe which produce but few – in all animals the firſt production is fewer than the reſt—in temperate climates and among the moſt civilized people, the greateſt diverſity, mixture and moſt numerous varieties in each ſpecies of animals are to be found——animals inſtead of increaſing with their age diminiſh in faculties and talent——animals in general are only in a ſtate of engendering when they have received the greateſt part of their growth, but thoſe which have a fixed time for rutting or ſpawning ſeem to make an exception to this law —— in quadrupede animals, thoſe which like the Stag, Elk, Deer, Rein Deer, Roebuck, &c. have a fixed time for rutting, engender much ſooner than other animals—the violent death of animals is a legitimate and innocent cuſtom, ſince it is founded in nature, and they only exiſt on that condition——animals which have but one ſtomach and ſhort inteſtines, are found like men, to feed on fleſh—proofs of this aſſertion. ——All animals that are perfectly white have red eyes——animals are almoſt all debaſed – have preſerved only their individual properties—have loſt by duration as much and more than they acquired before man diſquieted them—animals which eat their tails—the in-
fluence

fluence of climate is much ſtronger marked in animals than in man—in hot countries terreſtrial animals are bigger and ſtronger than in cold or temperate countries, they are alſo more hardy and ferocious——the courage of animals is exalted or temperated according to the uſe they have made of their ſtrength—the impreſſion of the ſpecies is not unalterable—the nature of animals is leſs conſtant than that of man, it can vary and change by time—animals in hot climates connot produce in cold, when even they are free and amply fed—moſt large animals of hot countries have little or no hair—the true country of animals is the land to which they reſemble, that is to ſay, the ſoil to which their nature appears to be entirely conformed, eſpecially ſince this nature of the animal is not modified elſewhere, and is not influenced by other climates——the order in the multiplication of animals is an inverted ratio of the order of ſize, and the poſſibility of the differences is in a direct ratio of the number in the product of their generation—there are therefore more varieties in ſmall animals than in the large, and for this reaſon there are more approaching kinds.——The internal part in animals is the ground work in the deſign of nature, it is the conſtituting form, the true figure, the external is only the drapery—this exterior part, often quite different, often covers an internal part perfectly ſimiliar, and on the contrary, the leaſt internal difference produces very great ones externally——the animals in general are more

more happy than man, the ſpecies among themſelves have nough to dread; evil has but one ſource for them, it has two for man, that of moral evil open to himſelf, is a torrent which affects the whole face of the earth; the phyſical evil on the contrary, is confined in narrow limits – it rarely goes alone, good often ſurmounts it, or is at leaſt on a level with it.—Ferocious animals whoſe hide is the moſt beautiful, have at the ſame time the moſt perfidious nature—compariſon of the education of animals with that of man—animals whoſe education is the longeſt, that is to ſay, thoſe which have longeſt need of the aid and cares of their mother, are thoſe which appear to have the moſt intelligence—in man the phyſiognomy deceives, but in animals we can judge of their diſpoſition by their mein—for what reaſon the alterations of nature are greater and more ſudden in animals than in mananim als whoſe ſpecies is iſolated are very few in compariſon of thoſe whoſe ſpecies are nearer and ſeem to form families or kinds——the genus of cruel animals is one of the moſt numerous and varied—fortunately proud animals are all ſolitary and do not herd——of animals which have talons, that is crooked and retractable nails, none is ſocial nor herds —— I. 204

Animals quadrupede, are only in a ſtate of engendering when their body has taken almoſt its full growth ——in all animals without excepting one, and even in man, the neck is compoſed of exactly ſeven vertebræ —— in general carnivo-

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rous animals have the neck much ſhorter than thoſe which are fed on graſs—there is ſcarcely in all the habitable and known earth above 200 kinds of quadrupede animals—quadrupede animals next to man are the beings whoſe nature is the moſt fixt and the form moſt conſtant—— quadrupedes whoſe parts of generation are renewed and obliterated every year nearly like that of the ſoft roe of a fiſh—their moſt general attributes are to have four feet and to be covered with hair, found common to all the firſt with animals of another order, ſuch as Lizard, Frogs, &c. and the ſecond is de cient to certain animals ſuch as the Tatou, Pangolin, who nevertheleſs are true quadrupedes—quadrupedes have greater affinity among themſelves than with other animals, nevertherleſs there are a great number which tend to other claſſes of nature; theMonkeyapproaches towardsMan: Bats are the monkeys of birds, which imitate them in their flight: Porcupines by the quills with which they are covered ſeem to indicate that feathers may belong to other animals beſides birds: Tatous by their armour approach towards the cruſtaceous claſs: Beavers by the ſcales on their tail reſemble fiſhes: Fourmillers by their kind of beck or bill without teeth, and by their long tongue recalls us again to birds: and laſtly, Seals, Morſes, the Manati, &c. are the links between the quadrupede and cetaceous kind——conſideration of quadrupedes under another kind of view—

it

it is without a sufficient reason that they have been generally termed quadrupedes, IV. 115, &c.——Among the 200 kinds of animals to which the common name of quadrupedes has been given, there are at least forty which are quadrumanous; twelve or fifteen bipedous and as many whose fore or hind feet are useless—Quadrumanous animals fill the great chasm between men and quadrupedes; the Bimanous like the Manati, are the nearer them, in the still greater distance between man and the cetaceous kind. The bipedous with wings form the link between quadrupedes and birds, and the fissipedous which make use of their fore feet like hands, fill up all the degrees found between quadrumanes and quadrupedes VI. 115, &c.

Animals Domestic and Wild, I. 367 —— Domestic animals vary prodigiously in colour in the same country, while wild animals vary by the colour in different climates —— Domestic animals, like men, are stronger, larger, and more courageous in cold countries; more civilized, and gentle in temperate climates, and weaker and uglier in hot climates. II. 82.——It is in these temperate climates and among the more polished people that the greatest diversity is found, as is the greatest mixture and the most numerous varieties in each species.——In domestic animals there are many evident signs of the antiquity of their slavery: pendent ears, varied colours, long and fine hair, are so many effects produced by time, or rather by the long duration of their domesticity.—Wild and free animals, are, perhaps, without exceptin[g]

rous animals have the neck much ſhorter than thoſe which are fed on graſs—there is ſcarcely in all the habitable and known earth above 200 kinds of quadrupede animals—quadrupede animals next to man are the beings whoſe nature is the moſt fixt and the form moſt conſtant——quadrupedes whoſe parts of generation are renewed and obliterated every year nearly like that of the ſoft roe of a fiſh—their moſt general attributes are to have four feet and to be covered with hair, found common to all the firſt with animals of another order, ſuch as Lizard, Frogs, &c. and the ſecond is de cient to certain animals ſuch as the Tatou, Pangolin, who neverthelefs are true quadrupedes—quadrupedes have greater affinity among themſelves than with other animals, nevertherleſs there are a great number which tend to other claſſes of nature; theMonkeyapproaches towardsMan: Bats are the monkeys of birds, which imitate them in their flight: Porcupines by the quills with which they are covered ſeem to indicate that feathers may belong to other animals beſides birds: Tatous by their armour approach towards the cruſtaceous claſs: Beavers by the ſcales on their tail reſemble fiſhes: Fourmillers by their kind of beck or bill without teeth, and by their long tongue recalls us again to birds: and laſtly, Seals, Morſes, the Manati, &c. are the links between the quadrupede and cetaceous kind——conſideration of quadrupedes under another kind of view—
it

it is without a ſufficient reaſon that they have been generally termed quadrupedes, IV. 115, &c.——Among the 200 kinds of animals to which the common name of quadrupedes has been given, there are at leaſt forty which are quadrumanous; twelve or fifteen bipedous and as many whoſe fore or hind feet are uſeleſs—Quadrumanous animals fill the great chaſm between men and quadrupedes; the Bimanous like the Manati, are the nearer them, in the ſtill greater diſtance between man and the cetaceous kind. The bipedous with wings form the link between quadrupedes and birds, and the fiſſipedous which make uſe of their fore feet like hands, fill up all the degrees found between quadrumanes and quadrupedes VI. 115, &c.

Animals Domeſtic and Wild, I. 367 —— Domeſtic animals vary prodigiouſly in colour in the ſame country, while wild animals vary by the colour in different climates —— Domeſtic animals, like men, are ſtronger, larger, and more courageous in cold countries; more civilized, and gentle in temperate climates, and weaker and uglier in hot climates. II. 82.——It is in theſe temperate climates and among the more poliſhed people that the greateſt diverſity is found, as is the greateſt mixture and the moſt numerons varieties in each ſpecies.——In domeſtic animals there are many evident ſigns of the antiquity of their ſlavery: pendent ears, varied colours, long and fine hair, are ſo many effects produced by time, or rather by the long duration of their domeſticity.—Wild and free animals, are, perhaps, without excepting man,

man, of all living beings the leaſt ſubject to alterations, &c.——captive animals and thoſe ſhut up in menageries do not attain their full growth, and do not live ſo long as thoſe which are free ——domeſtic animals are ſubject to more varieties than the ſavage——neceſſity of their degeneration——the ſtate of domeſticity ſeems to render animals more libertine, that is to ſay, leſs faithful to their kind, and renders them likewiſe hotter and more fruitful IV. 15, &c.
The domeſtic ſtate has cauſed the colour of their hair to vary.——the primitive and natural colours fallow and brown——many more varieties in the ſmall than in the large ſpecies——the reaſon thereof —— —— IV. 26

Animals of both Continents——animals of the old Continent which are not met with in the new—— animals natural to the new world——their individuals extremely numerous in each ſpecies—— reaſon thereof —— II. 328, &c.
Animals proper and particular to the new Continent——enumeration of animals belonging to both continents —— all the animals which have been tranſported from the old continent into the new, are become ſmaller, and all thoſe found in both continents are likewiſe ſmaller in the new without exception.---American names of animals of the new continent——there were but five ſpecies of quadrupede animals at St. Domingo when it was diſcovered, the largeſt of which was the Squirrel V. 331, &c.

Animals belonging to both Continents, are much leſs than

than thoſe of the old —— II. 238
Enumeration of their differences II. 243
All the animals belonging to both continents may be reduced to five races, and nine iſolated ſpecies——enumeration of them——diſtant affinities which ſeems to indicate ſomething common in the formation of animals of the two continents

Animals proper and particular of the new world, their origin cannot be attributed to ſimple degeneration —— IV. 66, &c.
When the two continents were contiguous, the ſpecies which were quartered in the countries of the new world, have been probably ſhut up there by the irruption of the waters, when they divided the two continents——poſſibility of this event —— —— IV. 68

Animals and *Vegetables*.——There is no abſolute and eſſential difference between animals and vegetables——nature deſcends by degrees or imperceptible links from the animal which appears the moſt perfect to that which is leaſt ſo, and from that to the vegetable——therefore they are nearly beings of the ſame order Ditto 70

Anta or *Ant*, is the ſame animal as the Tapir——origin of the name Anta —— III. 173

Antilope, kind of gazel found in Barbary and Arabia, &c.——its deſcription —— Ditto 32

Apar, a kind of Tatou——its deſcription and ſyrecific characters – its fleſh as white and as good food as the ſucking pig —— Ditto

Ape, a name which the Engliſh give to the monkey without a tail —— Ditto 220

Aperea——possibly the same animal as the Coril IV. 101

Arabia, the Deserts of—description of the sand and burning Deserts ——

Arabians, history of the I. 212, &c.

Archipelago, Indian——appears to be an inundated country —— —— I. 213

Archipelago inhabitants of the, are excellent swimmers —— —— Ditto

Argali, of Siberia the same as the Moufflon

Argilaceous earths and *clays* are only vitrifiable sand decomposed, and these clays by decomposing change into mud — proofs of this assertion—— may become flint —— V. 430

Art.—Comparison of the works of art and nature Ditto

Arts.—All the ideas of arts, have their model in the productions of nature —— VI. 3

Asia.—All the oriental continent is the most ancient land of the globe——the western coasts of Europe and Africa are the most modern ——

Attachment to inanimate things is the last degree of stupidity —— difference between attachment and friendship——causes and reasons for the attachment of mothers for their young in animals ——physical cause of the attachment of parents to their children —— I. 294, &c.

Attraction mutual and general in all parts of matter, whether in the earth, planets, &c.—the laws of attraction, or of affinity, by which parts of different

ferent mineral substances attract each other IV. 447, &c.

Attractions, the law of affinities and the law of attraction are not one and the same, and if those of affinities appear different from the general law of attraction, is, that in affinities the figure enters as element in the expression of the distance; whereas in the attraction of celestial bodies the figure does not in any manner enter into the expression of the distance Ditto

Aurochs or *Urus* the same animal as our bull in its wild state ——the primitive race of all oxen and bisons —— III. 134 to 149

Axioms—we must not rely on absolute ones Ditto

Axis, is the same animal as one vulgarly known by the name of, in the Ganges II. 161

B

Babiroussa, Its resemblances and differences with the hog ——Description of its tusks ——of a finer ivory, but not so hard as that of the elephant — — III. 372, &c.

Baboon, an animal belonging to the Old Continent ——Its definition——The antients had no proper name for this animal—Baboon, a generical name comprehending three species——Short description of them, — III. 460, &c.

Bats—have fore paws—neither feet nor wings—their enor-

enormous deformity—natural habits——lives on flies and insects——true quadrupedes which have nothing in common with birds but their flight ——live many days without eating—of the number of the carnivorous—Five new species unknown to naturalists — II. 247, &c.

Bear, white—Cannot positively affirm that white sea Bears of the north are of a different species from that of the common Bear—critical discussion thereof—Travellers description—Natural habits——their voracity——feed on seals and small whales - IV. 81 to 85

Bear of the Sea or white Bear—is a quite different animal from the land Bear——two kinds of land Bears—white land Bears—brown Bears of the Alps—ferocious and carnivorous——the black is only wild and constantly refuses flesh—its natural habits—red and brown Bears carnivorous and devour living animals——the brown generally dispersed in cold, temperate, and hot climates——but the black found only in cold ——not found in countries which are peopled ——its characters and habits——excessively fat at the end of autumn——when they copulate ——manner in which the mother feeds and rears her young ——- nature and temperament—susceptible of education——manner of hunting it——the flesh of the young delicate and good as are its feet——use of the flesh, fat and skin——why they suck their paws in winter an excellent smell—coarse resemblances of its limbs with the arms and legs of man——II. 170 to 280

Beaver—it is not strength nor physical necessity like Ants,

Ants, Bees, &c. that they labour and build ——— their ſociety, choice, and common views among thoſe that form it —appear below the dog, elephant, &c. for individual qualities—its character and nature——the only animal among quadrupedes that has a flat and oval tail with ſcales—the only one that has fins and webs to the hinder feet, and toes divided in the fore feet—the only one which reſembling terreſtrial animals by the anterior parts of its body, appears at the ſame time to incline to the aquatic by the poſterior parts of its body—begin to aſſemble in June or July, and form bodies of 2 or 300——their rendezvous at the borders of rivers, &c. ——The largeſt weigh 50 or 60 pound, and ſcarcely three feet long——deſcription of their labours and account of their conſtruction—manner in which they eat and deſtroy trees——they make very conſiderable proviſion of bark and tender wood and each cabin has its ſeperate proviſion—they give notice of an enemy by ſtriking the water with their tail——a noiſe which reſounds throughout all their habitations —they ſometimes travel to a diſtance on the ice —the fleſh of the anterior parts to the reins, has the taſte, quality and conſiſtence of animal fleſh, that of the thighs and tail the ſmell, ſavour, and all the qualities of that of fiſh———their fur good in winter———ſolitary Beavers ——difference of theſe from others ——— II. 280, &c.

Thoſe of the northern countries have the fineſt and blackeſt fur ——ſome mixed with white—— can ſubſiſt and live out of water——its fur compoſed

poſed of two kinds of hair—caſtoreum an odrife-rous matter furniſhed by this animal——ſwims better than it walks——it has received a gift from nature nearly equivalent to that of ſpeech II. 289 to 299.

Beauty,—ideas of different people about it—among the ancients what —— I. 72, &c.

Bees,—examination of their pretended knowledge—their ſociety only a phyſical aſſemblage ordained by nature, and independent of all views &c.—proof thereof —— I. 361, &c.

Bengal, natives of —— I. 102

Biſon—ſhort deſcription of that of America Ditto

Biſon, or *hunched Ox*——forms not a particular ſpecies, and is only a variety in the ox ſpecies——its difference from the Aurochs——advantage of this over the common race of oxen——deſcription of their hunch and quality of their fleſh III. 134, &c.

Bitch pregnant—experiments on her and her puppies I. 40, &c.

Bitumen—its ſource - bitumen and ſalt are predominant matters in the ſea ——

Bobak is a Marmoſe found in Poland and which ſcarcely differs from that of the Alps, only by the colour of the hair and by a claw to its fore feet —— —— III. 318, &c.

Boar Wild—— difference of the wild boar and domeſtic Hog——duration of its life——young follow their mother till the age of three years——the male very ſeldom cries but when it is ſurprized—it

it makes a noiſe ſo as to be heard at a great diſtance—not naturally carnivorous—the male remains thirty days with the female in the rutting time —its chace —its genital parts muſt be cut off immediately as its killed or its fleſh is uneatable —— III. 134, &c.

Bubalus——its deſcription, differences and reſemblances with the Stag, Gazel and Ox——ſingularities in the form of the hair of the Bubalus and Elk—their difference—varieties in this ſpecies—its climate and habits III. 250 to 253

Buffalo belongs to the old Continent—not known by the Greeks or Romans——the indian of the ſame ſpecies as the domeſtic and wild in the Indies ——does not copulate nor produce with the Cow——antipathy of theſe two kinds—its nature, temperament, habits and its difference with the Ox—the fourth in the order of ſize among quadrupedes—more tractable in hot than in temperate climates, and runs better than the Ox —— —— III. 134, &c.

C

Cabiai—animal of South America, which did not exiſt in the old Continent—its differences and reſemblances with the hog—its deſcription—ſize, figure, &c.—has membranes between the toes and often inhabits the water, where it ſwims with great facility — its nutriment and other natural habits—it produces a great number—the Cabiai has no external reſemblance

r to

to any other animal, although by the internal part it resembles the indian hog III. 274, &c.

Cachicame kind of Tatou—its description and characters — — III. 42, &c.

Caffers, description of, — I. 253

Calculi—stones formed in the bladder of animals are of a substance and composition quite different from that of bezoar III. 249, &c.

Callitrix. In Greek signifies fine hair, and this name is applied to the monkey with a long tail, whose coat is of a fine green, the belly of a beautiful white and the face of a fine blue — — — IV. 13

Callosities on the breast of Camels, Lamas, and on the buttocks of Baboons, and Monkeys—their origin and how they are produced Ditto

Calmar—its seminal liquor, and even the roe which contains it, is formed and obliterated every year — — IV. 275, &c.

Calmucks—the most ugly people in the world I. 176, &c.

Campagnol—natural habits—do great injury to corn—difference from the water rat—bring forth in spring and summer five or six at a time—destroy one another when there is a scarcity II. 334, &c.

Castration—the use of it, very antient and very generally dispersed—performed in different manners—not dangerous—may be performed at any age—infancy least so — I. 40

Cay-

Cayapolin—ſhort deſcription of it—its conformities with the Marmoſe and Sariga—three animals proper and particular to the hot countries of the new Continent — III. 64, &c.

Cetaceous animals — the life longer than that of quadrupedes — III. 378

Chacrelas—race of ſavages called white negroes I. 269

Camel—don't ſucceed when tranſported to America —two hunches on its back, whereas the dromedary has but one — produce together—the camel race not ſo numerous as the dromedary's — country where found — endeavours to propagate their ſpecies in Spain—in their native country infinitely uſeful——their milk the common food of the Arabs; they alſo eat their fleſh, and particularly the young——its hair fine and ſoft——renewed every year——manner of rearing them — can travel 300 leagues in eight days without ſtopping and eat little——travel for ten days without drink—when the Camel is overloaded, refuſes to riſe —manner in which they make them travel—the Camel ſeems to prefer wormwood, &c. to other ſweeter herbs—their abſtinence from drink, not entirely from habit, but conformation—have one ſtomach more than other ruminating animals—its nature conſiderably altered — he bears marks of its ſlavery, beſides the hunches on its back—but one ſtallion camel for eight or ten females—they are furious in ruting time—couple like other animals goes a year and produces but one—female

camels

camels ſeldom labour—from the profit of their produce, milk, &c.—their hunches diminiſh as they grow thinner — III. 130, &c.

Chace—the moſt healthful exerciſe for the body, and the moſt agreeable repoſe for the mind I. 89

Cat—character and nature—the female more violent than the male—the females hide themſelves to kitten—the males accuſtomed to devour the young one and the mother alſo—Cats of themſelves become excellent hunters although they have not a delicacy of ſmell—phyſical cauſe of their inclination to watch and ſurpriſe other animals—Conformation of their eyes—they ſee beſt at night, when it is not too dark—Cats are abſolutely domeſtic animals—more Cats are in general reared than dogs—Cats have leſs attachment to perſons than to houſes they frequent—they dread cold water, noxious ſmells and perfumes—Cats eat ſlowly and with difficulty—reaſons thereof—they ſleep leſs than they make ſhew of—the wild Cat produces with the domeſtic, conſequently both are one and the ſame kind—the domeſtic Cat is generally longer and thicker than the wild—character of the wild cat compared with the domeſtic—differences of cats relative to the climate—how the varieties are produced in the ſpecies of cats—not like that of the dog, ſubject to vary when tranſported into other climates — II. 69 to 80

Chevrotin—many varities in this ſpecies—can live only in exceſſive hot countries—they are ſmaller than

than other forked feet animals—not found in America — — IV. 259, &c.

Chinese—their description and resemblance with the Tartars — — I. 182

D

Death—causes of—why should it be dreaded—an easy removal—hope quits us not till the very moment of—produced by a very acute pain—not to bury our fellow creatures till we are certain of their I. 40

Deer Fallow—less robust and savage than the Stag—most in England—almost a domestic animal—its horns and their differences from Stags—their rutting time three weeks before that of the Stag—their battles during that time—their natural habits and stratagems to escape from the hounds—very easily tamed and eat many things which the Stag refuses—these and the Roebuck are the only species of animals common to both Continents that are larger and stronger in the new than in the old —— II. 114, &c.

Degeneration—physical explanation of it in animals and plants—the temperature of the climate, quality of food and the evils of slavery, are three causes of the change, alteration and degeneration in animals — — IV. 1.1, &c.

Deluge we cannot explain by it the transportation nor position of marine productions, which is found in such great quantities in the bowels of the earth —— —— V. 322

The

The Universal Deluge has been made by the immediate will of God and not by natural causes V. 407, &c.

Derision and *Contempt*—their expression I. 8

Douc is neither precisely of the race of Monkies, nor of that of Baboons, nor of that of Apes, but participates of all three—the only monkey that has hair on its posteriors—very easily distinguished from the rest—its description—where found—distinctive characters — IV. 9, &c.

Dressing — view of — I. 63

Downs — formation of — VI. 11, &c.

Dromedary, is not a different kind from that of the Camel but a variety thereof — has only one hunch on its back, whereas the Camel has two—its race the most numerous and more diffused o'er the earth than the camel — enumeration of the countries where this race is found — the most sober of all animals and can live many days without water — its feet proper for walking on the sands, and cannot stand in moist and slippery ground — III. 122, &c.

E

Earth — infinite number of trees found thereon V. 208, &c.

Education—there are two kinds—that of the individual common to man and animals, and that of the

the ſpecies which belongs only to man — a child is much ſlower than an animal in receiving individual education, and it is from this reaſon that he becomes ſuſceptible of the ſpecies — the education of a child muſt be cloſely followed and always ſupported — this neceſſary, continual and common habit between the mother and child during ſo long a ime, is ſufficient to communicate to it all what it poſſeſſes; and if we even ſhould ſuppoſe it to poſſeſs nothing, not even ſpeech, this long habit would ſuffice to produce and this firſt ray of intelligence ſupported, cultivated and communicated, afterwards opens the germs of thought — III. 422, &c.

Egypt — the ſoil of the northern part formed by the depoſits and ſediments of the waters of the Nile — this mud at preſent above fifty feet thick V. 339

Elk — found in North America, where it is called Orignal — deſcription of and compariſon with the Stag — natural habits — when it runs, the bones of its feet make a crackling noiſe which is heard at a diſtance — a ruminant animal — characters of the elk — doubt on that ſubject — has very thick hair and tough fleſh — it has very great ſtrength in its fore feet — method in which the ſavages of America chaſe the Orignal or Elk during winter — III. 193, &c.

Elephant by means of its trunk which ſerves it like a hand, has the ſame addreſs as the ape — is docile and ſuſceptible of a very ſtrong attachment like the dog — its nature, qualities, underſtanding, &c. — veneration of the Eaſtern people for

for elephants, eſpecially for the white——have ſocial manners——the order which they follow in their walking——although very heavy, his pace is ſo great that he eaſily overtakes a man that runs— is ſuſceptible and tender of injuries —has an excellent ſmell probably more perfect than any animal——likes moiſt places and often fills his trunk with water—ſwims very eaſily—the reaſon thereof —— the quantity of food it conſumes in a day — deſtroy more than they eat — the ſpecies is confined to the ſouthern parts of Africa and Aſia — made uſe of in war by the ancients and would be uſeful now — why — they ſeem ſo much the more content as they are more richly clad—— ſtrength of the elephant——the diameter of their feet—method of treating it—duration of its life——different colours——the ſmalleſt have ſmall eyes in proportion to the body —moves its ears with great facility, and makes uſe of them to wipe his eyes and to preſerve them from the inconvenience of duſt and flies—his ſmell exquiſite——delighted with the ſound of inſtruments — deſcription and uſe of the trunk ——of all the inſtruments with which nature has been liberal, the trunk is perhaps the moſt complete and admirable —— a ſenſe — phyſical cauſe of the Elephant's ſuperior underſtanding—the tuſks become enormouſly heavy with age—cannot take up any thing from the ground with the mouth—manner in which it drinks—the young Elephants not to ſuck with the mouth—the teats of the female, two, ſituate on the breaſt

breast——do not couple like other quadrupedes III. 461, &c.

Envy—its expression — — — I. 80

Egret—a variety in the species of the Macacco, III. 461, &c.

Etna—we may dig to the depth of 60 feet in the matters ejected from this mountain — description of it—its eruptions — — VI.

Experiments and *improvements* for the vegetable creation — — — — — VI. 24
——— on trees, oaks, &c. V. 26

Exposition of trees, &c.—to defend them from frost and bad weather — — Sup. VI. 16

Evaporation alone raises great quantity of water from the ocean, &c. — VI. 85, &c.

Eyes—the most beatuiful — I. 54

Eyelids—use of — — I. 59

Eggs—formation and growth of—exist not in viviparous females—have a kind of life and organization, growth, developement, and a form which it takes of itself—the egg vegetates not like a plant—a being which must be considered apart—eggs are portative matrices which the animal throws out, &c. — I. 184, &c.

F

Falsity bears a much more extended signification in philosophy than in morality — IV. 166

Family—the Horse, Zebra and Ass appear all to be all of one and the same family—it is the same with respect to many other animals whose species approach each other—the reduction of quadrupede animals into a certain number of families — — — IV. 30, &c.

Fecundation—the state in which the embrio is in the egg when it is laid by the hen, is the first state which immediately succeeds fecundation, and that the form in which we then see it, is the first form resulting from the internal mixture and from the penetration of the two seminal liquors — — — — Ibid.

Fear—description of — — — I. 80

Females—of certain animals will serve the males of different species and produce with both—contribute more than the males to the support of the species, the female having greater influence on the specific nature of the production — IV. 33, &c.

Fermentation—causes of, in animal and vegetable

Ferrets—which resemble Polecats—native of hot climates

climates——eaſier tamed than the Polecat——its ſmell ſtrong and diſagreeable——its coat varies ——produces twice a year and ſometimes devours its young——naturally a mortal enemy to the Rabbit——manner of making uſe of the Ferret to catch Rabbits——natural habits and temperament —— —— II. 211, &c.

Fire——general and particular means of producing it——origin of fire, heat and light——properties of it——air the firſt food of it and not combuſtible matters——abſorbs air and deſtroys its ſpring—different modes of augmenting it——minute examination of its nature——flame not the hotteſt part of fire——communicates by light —— —— IV. 435, &c.

Fires—ſubterranean do not proceed ſolely from a central fire, and at no great depth — V. 345

Fiſſipedes—enumeration of them —— III. 415

Fiſh——reaſon why they live longer than other animals——the ſcaly oviparous IV. 34, &c.

Flux and *reflux*——acts with greater force under the equator than elſewhere——its motion has produced mountains, and all the great inequalities of the terreſtrial globe V. 344, &c. The waters at the bottom of the ſea undergo the ſame motions of flux and reflux as thoſe of the ſurface —— VI. 96, &c.

Fœtus. Formation——deſcription thereof through-

out

out all its degrees of growth —— lives, expands and grows by intussusception —— developement thereof from conception —— seven days after conception we can distinguish by the naked eye, the first lineaments of the fœtus, &c. IV. 351, &c.

Fossan. A pretty animal of Madagascar— its nature, habits, food, &c. III. 326, &c.

Fouine and *Martin* — two distinct and seperate species— differencies to prove this II. 203, &c.

Fouine is generally dispersed —— character and natural habits —— partly to be tamed — generally in continual motion, and sleeps sometimes for two days together —— its vesicles c—— odoriferous matter —— &c.

Fox. Character and natural habits of ——— its cunning— manner in which it hides and deposits in different places its prey —— its mode of hunting —— that of hunting it — carnivorous and voracious —— fond of honey —— its difference from the dog —— not easily tamed —— method in which the female conceals and rears her young ——— different tones of voice—— sleeps found ——— numerous varieties in the species ——— never found in hot countries —— the fur of the white, not much esteemed —reason thereof, &c. - II. 189, &c.

Gazelle;

G

Gazelles. Thirteen species or varieties——in general resemble the Roebuck, but their horns are permanent——difference between them——enumeration of all the kinds of Gazelles most of one half domesticated——manner of hunting them——have fine eyes——fore legs shorter than the hinder——which facilitates their running or leaping——have cloven feet——the horns of the female shorter than those of the male - III. 229, &c.

Generation——explanation of, in the human and animal species——in what manner it is performed in different animals——grand question on the subject of generation——why nature employs the mode of sexes for generation in most animals——answered——physical reason why old people are incapable of generation——why monsters are produced from the marriage of decrepid persons and old with young ——— — IV. 449, &c.

Gerbua——this animal found in the east——its nature, extraordinary manner of walking——its manners, &c. - III. 319, &c.

Gibbon. Animal of the Indies——the third race of monkeys ——— Ditto 456

Girl. In the woods of France - I. 262

Giants.

Giants —— Ditto 274

Glutton—ſhort deſcription of the—often been confounded with the Hyena although a very different and remote ſpecies—eats fleſh, fiſh, &c. follows the Icatis, which ſerves him as a purveyor——natural habits, &c III. 350, &c.

Goa —— I. 207, &c.

Gulphs——enumeration of——the ſmall gulphs at the mouth of the Indus is a part of the world where the effects of the tides appear the greateſt——the Mexican gulph is a Mediterranean ſea where the motion of the tides is ſcarcely more ſenſible than in ours——reaſon thereof —— VI. 59, &c.

Grimmius —— its deſcription —— difference from the Gazel —— the female has no horns, III. 256, &c.

Greenland —— old Greenland, where the Danes had erected cities and looked on as one of their provinces for two or three centuries, is now no longer ſubſiſting; or, at leaſt not to be found by travellers VI. 76, &c.

Greeks——deſcription of the — I. 23

Guiba——animal of Senegal, its differences and reſemblances with the Gazelles——deſcription of——its climate and natural habits III. 256, &c.

Guzurat —— I. 206

H

Hair——defcription of the — I. 59

Hamfter——is one of the moft famous and noxious rats, refembles more a water rat than any other—defcription thereof—conftruction of its habitation, &c.——the production of the female —— varieties in this fpecies —— eat and deftroy each other —— their coat good fur — III. 312, &c.

Heat—principle of—difference of the fun's rays —fixed in bodies—ftrong the interior part of the globe —— —— IV. 444, &c.

Hedgehog—defends itfelf againft dogs, by rolling itfelf up in the form of a ball—the Fox kills it——manner of their copulation, production, &c.—when the mother devours her young—a malicious animal—natural habits of——fleeps in winter—only one fpecies—not found in cold countries—manner in which the Fox conquers it II. 240, &c.

Hippopotame—belongs to the old Continent and not found in the new——the fpecies not very numerous——its fkin very hard, thick, and almoft impenetrable—— its meafure and dimenfions——number of teeth, &c.——produces but one at a time——the male one third larger than the female——its nature and manners——not found in the

the temperate or northern climates III. 187, &c.

Hog—the, and that of Siam and the Wild Boar of the fame fpecies——four toes, two of which only appear exteriorly——comparifon of the Hog with folipedous, forked and fiffipedous animals——Hog multiplies more than any other animal of the fame fize—— its difference in the fat from all other animals——fingularity in the form of its teeth——has four teeth—nature and qualities—ftupidity——imperfection in its tafte and feeling——diforders——manner of rendering its flefh excellent food—different modes of fattening them——caftration——the growth of the Hog——white Hogs not fo ftrong as the black — — — II. 24, &c.

Hottentots—are not a race of negroes, but belongs to that of the Caffres—defcription——the women have an excrefcence of fkin on the os pubis which ferves them for an apron——ceremony of caftration among them—comparifon of the Hottentot with the Monkey — I. 245, &c.

Hyena—belongs to the old Continent and not found in the new—refemblance and difference of the Jackall and Hyena——deftroys dead bodies——its refemblances and difference from the Civet and Baboon—Hyena and Glanus, names ufed by Ariftotle are not two different animals——a folitary animal—has long and naked ears and four toes to the feet—its particular characters by which it differs from all other animals—natural habits—

an

an animal of prey, strength and ferocity——absurd fables and stories of this animal II. 420

Hymen—membrane of—opinion for and against the existence of it —— I. 48

J

Jackal——description of——natural habits, &c. III. 340, &c.

Japanese of the same race as the Chinese I. 186

Ichnewmon—description of —— III. 323, &c.

Imagination—or longings of the mother cannot produce any internal nor external effect on the body of the foetus —— IV. 908, &c.

Impulsion—the force would be executed in the tangent of the orbit of planets, if the power of attraction ceased one moment — V. 353, &c.

Incubation —— IV. 186, &c.

Infibulation——for boys and girls ——mode of the operation —— I. 39, &c.

Infinite—nothing truly so — IV. 440, &c.

Inundations——reflections on——are generally greater in the upper parts of rivers than in the lower, and those adjacent to their mouth—inundations of the Nile—periodical in large rivers—inundations are not so violent now as formerly VI. 39, &c.

Isatis—an animal of the north, whose species appears to be intermediate between the Fox and the Dog —it has been looked on as a variety of the Fox generally found in climates near the frozen sea —resemblance to the Fox and the Dog—description of—its voice inclines to the barking of a dog—its fur very beautiful and much sought after —its mode of copulation, production, &c.—its natural habits and manner of hunting it——found in North America III. 356, &c.

Islands——only the summits of vast mountains V. 315, &c.

K

Kabardinsher——a people uncommonly beautiful among the Tartars, who are extremely ugly I. 181, &c.

L

Lakes. Some lakes have subterraneous correspondences with the adjacent seas I. 319 —no lake found on the summits of mountains—— ibid 351, &c.

Lama and *Paco*—found only in the new world and inhabit only the mountains of South America—the only domestic animals of the ancient Americans, and the Spaniards still make use of

of them to carry heavy burdens, &c.—carry 150 or 200 lb. weight—ſcarcely go more than five or ſix leagues a day——grow very faſt——production, uſe——their nature appears to be modelled on that of the original Americans, are gentle, flegmatic, &c. ——deſcription how they are fed, &c.——their other natural habits—deſcription of it——the wild Lama found on the mountains of Peru and Chili—natural habits——very vigorous in the higher parts of the Cordilleros, but weak and languiſhing in the lower parts III. 292, &c.

Laplanders. Their figure, nature, manners, and cuſtoms——lead a diſmal life, nevertheleſs not unhealthy and attain to a great age——ſubject to blindneſs — I. 173, &c.

Leming——deſcription of this animal, chiefly inhabits the mountains of Norway and Lapland, but ſometimes they deſcend in ſuch great numbers that their arrival is looked upon in a terrible light——the male larger than the female——natural habits—the fleſh bad and its fur uſeleſs —— III. 363, &c.

Lerot or *middling Dormouſe*——its natural habits——fleſh not eatable like the great Dormouſe, &c. —— II. 253, &c.

Leopard. Equivocal application of this name——ſhort deſcription of the animal to which we apply it——natural habits——not tamed like the Ounce—its differences with the Panther and the Ounce——the ſpecies ſubject to varieties

——its fur valuable and dearer than that of the Panther and Ounce — II. 403, &c.

Light——a compounded matter——time of coming from the ſun, &c. VI. 435

Lion—its character and nature—the Lions which dwell on the higheſt mountains, are leſs ferocious than thoſe who live in the plains when the heat is exceſſive——the ſpecies is not very numerous—the Lions of the deſerts are much more intrepid and courageous than thoſe inhabited countries —— its motions in walking, &c.——— manner of hunting it II. 306, &c.

Lioneſs—one fourth ſmaller than the lion——has four teats ——when in heat purſued by the males, when they attack each other furiouſly —terrible when ſhe has young—ſeldom ſtirs out in the day — Ditto 325, &c.

Loir or *great Dormouſe*—three kinds—differences—do not ſleep naturally in the winter—a ſtate of ſtupidity or torpor—proof of this aſſertion by the thermometer——when they are cold they will roll themſelves up like a ball—part of the food of the Romans—not ſo tame as the ſquirrel, &c. Ditto 256, &c.

Lori—a little animal found in Ceylon — quadrumanous—its deſcription and compariſon with the Maki — III. 332

Lynx—two different races in the — difference of the northern and ſouthern—an animal belong-

ing

ing to cold and temperate climates—common to the old and new Continent—the Lynx of the ancients that could see through walls, fabulous—has the properties and manners of a cat—its cry like that of the wolf—differences from the Panther and Ounce——manner of its hunting and catching animals II, 410, &c.

M

Manati—under this name we comprehend the Lamantia or Manati of St. Domingo, &c.——origin of this name——not entirely cetaceous——its description——again after Oviedo——never goes on land and prefers sweet to salt water——its length—found on the borders of the Atlantic and Pacific sea——copulates in the water at a great depth——has no fore teeth ——another description——historical facts III. 393, &c.

Mandril——a large ugly Baboon——its description——its comparison——found in the southern provinces of Africa——next to the Orang Outang the largest of all Monkies——walks erect——fond of women——distinctive characters —— III. 464, &c.

Mangabeys——monkies of Madagascar —— vary much——appear to form the link between the Makis and the Monkey III. 476, &c.

Marble—the most ancient monuments of——left us by

by the Romans full of ſhells like the marble at preſent out of quarries — V. 473

Margay—name of a ferocious animal of Braſil——comparifon with the Wild Cat——its ferocity—natural habits—varieties—found in many parts of America —— III. 339, &c.

Marikina—vulgarly called the little Lion Monkey—its deſcription——natural characters, &c. IV. 77, &c.

Marly la Villa—ſix leagues from Paris —the ground formerly the bottom of the ſea which is raiſed 75 feet as we find ſhells at that depth V. 436

Macacco—of Monkies is that which has the neareſt reſemblance to the Baboon — hideouſly ugly——found in many parts of Africa—many varieties—one of them called the Egret—reaſon thereof—ſmells like muſk—go in droves—manner in which they pillage a field or garden III. 469, &c.

Madagaſcar—inhabitants—deſcription of I. 251,&c.

Magot—an animal between the monkey and Baboon ——the Magot beſt agrees with our climate——its nature, manners, food, ſize, &c.——has callofities on its hind parts——Magots of different ſizes and colours, generally diſperſed in all the climates of the old Continent—diſtinctive characters, &c. —— III. 451, &c.

Maimon or *Pigtail*—its reſemblances to the Baboon and its differences—its deſcription and nature—found

found in the ſouthern parts of India—diſtinctive characters ——— III. 467, &c.

Makis—animals of the old Continent not found in the new—a generical name under which we comprehend three ſpecies—general differences of them ——— particular deſcription of them III. 328, &c.

Malbrouck—kind of Monkey—its reſemblances with the Macacco and differences——characters &c. ——— III. 473, &c.

Maldivian Iſlands—which together are 200 leagues in length, formed formerly only one land, a ſummit of mountains compoſed of the ſame kind and ſubſtance ——— V. 446, &c.

Marmoſe——ſmall quadrumanous animal——its conformities and differences with the Sariga——the female no paunch under its belly like the Sariga, &c. ——— III. 67, &c.

Marmot—taken young—eaſier tamed than any other wild animal——detail of what it is capable of learning—natural qualities of it——purs like a cat ——drinks milk greedily——when irritated or ſtruck its ſhrieks ſo ſharp that it hurts the ear—delights on mountains and never found elſewhere ——deſcription of the borow of the Marmot—Marmots live together and work in common at their habitation——fat in autumn II. 264, &c.

Marle——compoſed of nothing elſe but the waſte and deſtroyed parts of ſhells III. 429

Marriage——its felicity and neceſſity I. 54, &c.

Martin——natural to the north climate——the kind very numerous there—not found in hot countries—natural habits—their fur beautiful II. 206, &c.

Mazames, of America——the ſame animal as the Roebuck —— III. 261

Microſcopical Experiments——the objects which Leewenhoek has cauſed to be engraved are repreſented much larger than he ſaw them IV. 246, &c.

Minerals—introduction to the hiſtory of IV. 431 Experiments thereon, &c. V. 53, &c.

Miracles——nothing better characteriſes a miracle than the impoſſibility of explaining the effect by natural cauſes —— V. 408

Molecules—organical in nature——there is an infinity of ſmall parts of living organized beings——theſe molecules are common to animals and vegetables—primitive and incorruptible parts—their aſſemblage forms organized beings to our eyes IV. 121, &c.

Mona —— the ſame as the Kebos of the Greeks ——— its coat of different colours which the name Kebos indicates — a kind of Monkey with a long tail — found in Barbary, Arabia and Perſia was known by the ancients —— called Nonne by corruption — reaſon thereof — its manners, natural habits, food &c.——diſtinctive characters —— III. 477, &c.

Moun-

Mountains—the great chain of mountains found nearer the equator than the poles——in the old Continent they extend from east to west——mountains have in all places correspending angles——reasons why the greatest inequalities of the globe are found nearest the equator—the highest are in South America and Africa——those of Asia and Europe although very great are not so high——mountains have not been produced by earthquakes——continually lower by rain——origin of mountains according to Schewchyer, Steno, and Ray I. 318, &c.

Moustac——a small Monkey remarkable for the whiteness of the upper lip and two tufts of yellow hair above the ears——distinctive characters of this species —— IV. 3, &c.

Morse, the—vulgarly called the Sea Cow, has nevertheless no affinity with the land Cow—those who have called it the sea elephant have better denoted it—imperfections of natnre in the Morse—historical facts on this subject—cannot always stay in the water —— their food and other natural habits III. 384, &c.

Mortality—tables on the, of the human race, approaching nearer the truth than any known before —— —— I. 96

Mouse, field —— provision of —— the large and small kind of the same species — description of their holes — easy method of catching a great number of them — very numerous in autumn II. 229

Mouſe, Shrew — inclines to the Rat and Mole — has eyes ſomewhat larger than the Mole — a ſtrong ſmell — not venemous nor capable of biting a big animal, therefore the wounds it is ſaid to give to horſes is not true — varieties II. 241, &c.

Mouſe, Water — places where found — differences, &c. — — Ditto. 243, &c.

Mufflon—is the wild animal from which all the breeds of domeſtic Sheep are iſſued — its deſcription and conformity with the Sheep — cloathed with hair not wool — III. 159, &c.

Mule — the Horſe and the Aſs may produce with the great and little Mule — reaſon for this preſumption — the aſs muſt produce with greater certainty with the Mule than the Horſe — the Mule is as ardent in love as the ſhe Aſs and for that reaſon inclines to ſterility IV. 35, &c. Mule produces in hot countries and ſome times even in temperate — two kinds one called ſimply Mule proceeding from the union of the Aſs with the Mare—the ſecond which is ſmaller, and proceeding from the Horſe and ſhe Aſs—the Mule produces with the Mare an animal called Huinus or Guinus—experiments propoſed on the ſubject of mules—preſumption on the product of the experiments—the mule muſt produce more certainly with the Mare than with the ſhe Aſs, and the Shingle with the ſhe Aſs than with the Mare — IV. 32, &c.

Muſk Animal—belongs to the old Continent—deſcription of—its humour found in a bag or tumor—the bag filled

filled in its amorous time—no ways domeftic and appears to be confined to the moft eaftern part of Afia — — III. 267, &c.

Mufcardine or *Small Dormoufe*—leaft ugly of all rats —its figure and natural habits—fcarce in France and common in Italy and found even in the north —origin of its name — makes its neft on trees like the Squirrel—defcription thereof II. 260, &c.

N

Nagor. Kind of Gazel of Senegal ——Jaba has wrongly termed it, Mazame—its climate and defcription — III. 264, &c.

Nature is the fyftem of laws eftablifhed by the Creator for the exiftence of things and for the fucceffion of beings——Nature not a being but may be confidered as an immenfe power which embraces and animates every thing— this power flows from the divinity——time, fpace, and matter her means—the univerfe her object, life and motion her end——limits of her power——never quits the laws prefcribed to her— the external throne of divine magnificence, &c.——*Brute Nature*——picture of— hideous ——— II. 450, &c.

Nature——cultivated and animated——view of II. 458, &c.

Neceffity—moral——muft feldom form a proof in philofophy — VI. 10

Negroes. Negro children are often in a very incommodious situation to come at the nipple—description of — I. 22, &c.

Negro of Senegal—their description I. 238, &c.

Negroes of Sierra Leona and Guinea—their description—do not live so long as other men—the premature use of women the cause—description of those of Guinea, Juda, Arcade, Congo, &c. colour changes when sick—the blackest in the western part of Africa I. 240, &c.

Negro—dissected —— cause of their blackness I. 285, &c.

North, passage by the—some new ideas on this subject V. 417—passage by the— all travellers who have attempted to go to China from Europe by the north east have alike miscarried VI. 81, &c.

Nutriment or *Food* —— is greater with respect to animals which feed on grass and fruit than on those which feed on flesh—reasons thereof IV. 20, &c.

Night——physical cause of the fear which most people experience from the obscurity of—— I. 146

Nutrition. Clear and general ideas of nutrition in the animal and vegetable IV. 138

Objection

O

Objection—the moſt conſiderable that can be made againſt all ſyſtems — firſt anſwer to it IV. 168, &c.

Obſervations on the liquor in oyſters—in the water in which pepper had been boiled—on the water in which pepper was ſimply infuſed, &c. IV. 274

Ocean—the,—has a conſtant motion from eaſt to weſt, which is not only felt between the tropics but in every other zone—the Pacific ocean acts continually againſt the coaſts of Tartary and China—the Indian ocean does the ſame againſt the oriental coaſt of Africa—the Atlantic againſt all the eaſtern coaſts of America V. 335, &c.

Ocelot or *Catamountain*—an animal of America, ferocious and carnivorous—of the ſame nature as the Jaguar and Couguar—deſcription of the male and female—ſize—nature—different names given to them in their native countries—error in this reſpect—appears to be the moſt beautiful of all the carnivorous kind—the male more beautiful than the female—cruel, and at the ſame time timid—prefers blood to fleſh—nothing can tame it—its production II. 336, &c.

Oudatra—kind of muſk rat—its differences from from others—brief deſcription of this animal—the Oudatra can reduce its body—deſcription of

of the follicles which contain the perfume—conformities and differences with the Beaver—defcription of their habitations—manner of catching them — their fur valuable, and their flefh not bad food, &c. II. 442, &c.

Orang Outang — firft kind of monkeys, if we was to pay attention to its figure alone, it might alike be regarded as the firft of the monkey race, or the laft of the human — two kinds, one called *Baris* and the other *Drill*—explanation of—inftinct—of fitting at table like men — likenefs of the Orang Outang with man— anatomical defcription of — diftinctive characters of III. 432, &c.

Organical is the general workmanfhip in nature, and that which cofts her the leaft — organical matter, is in a greater quantity in infects than in other animals—this fuperabundance of it not being ufed in generation from the defect of organs, molds and unites itfelf entirely, under one form, which depends much on that of the animal, and which it in part refembles IV. 340, &c.

Organization, an organifed body every part of which is like the whole—is a body whofe organization is the moft fimple IV. 360, &c.

Orignal—the name of the Elk in North America III. 153

Ounce——origin of this name, with a fhort defcription of this animal—comparifon with the Panther and differences — nature and temperament

ment — the kind appear more numerous and general than the Panther—used for the chace in Asia——reason thereof——natural habits II. 397, &c.

P

Paca——burrows like the rabbit——short description of this animal, and comparison with the hair and rabbit —— inhabits the borders of rivers and other wet places——it is found only in the hot countries of South America ——its flesh very good food —— the flesh eat like that of a sucking pig——its skin a very beautiful fur——it produces often and in a very great number——belongs to the new continent and not found in the old III. 51, &c.

Paco and *Lama*—animals of Peru and which were the only cattle of the old Peruvians — they are only found in the mountains of Peru, of Chili and new Spain — the Paco belongs to the new continent and does not exist in the old——this species would be an excellent acquisition for Europe, and we should endeavour of propagating it in our mountains III. 242, &c.

Palmist——small animal which lives on the palm trees——it is neither squirrel nor rat—— its resemblances and differences — it is found only

only in the hot climates of the old continent —natural habits —— III. 21

Panther——belongs to the old continent, and is not found in the new——Panther, Ounce, and Leopard are three different animals, they have been taken one for another among naturlists —— short description of the Panther—— characters and temperament—the Panther, the Leopard and Ounce is found only in the hotter countries of the old continent II. 389

Papion—is the name given to the greater species of Baboons——produces only in temperate countries——are not of the number of carnivorous animals—they live on fruit, roots, grains, &c. —— III. 460

Passions—how and by what signs the different passions is marked on the face of man I. 80

Patas—kind of monkey, or monkey with long tail——description of —— III. 471

Peccary——its resemblances and differences with the hog——natural habits —— its flesh not bad food—-precautions to be taken that it has no smell—the hair or rather bristles rougher and shorter than that of the Boar III. 1, &c.

Peru——remarks on the form of the earth there V. 476

Perouasca—description of this animal — its skin a a good fur —— IV. 90

Per-

Perſians——deſcription of - I. 210

Petit Gris——found in the ſouthern parts of the old and new continent——its reſemblances and differences with the ſquirrel III. 18

Phalanger——ſmall animal of South America which we have called *Phalanger*, becauſe there are ſome ſingularly formed—of the number of the quadrumanous animals, and its ſpecies approaches that of the Marmoſe——characters, &c. III. 311

Philander, *vide*, Sariga

Philander of Surinam - IV. 99, &c.

Pinch——kind of Sagoin—its deſcription and characters —— IV. 78

Pitheros—ſecond kind of monkey—is the gentleſt and the tameſt of the whole, &c. III. 50

Pleaſure and *Pain*—a light too bright, a fire too hot, too ſtrong a noiſe or ſmell, &c. hurts or diſagreeably affects us; whereas a temperate heat, a delicate perfume, &c. is a pleaſure I. 323

Planets——formation of—explanation of the formation of——the principal planets are attracted by the ſun ———the ſun attracted by the planets——the ſatellites alſo attracted by their principal planets—they turn in the ſame direction round the ſun and almoſt in the ſame plan——formerly belonged to the ſun—reaſon why the

more dense planets are nearer the sun, &c. V. 355, &c.

Poisons—manner in which animal and vegetable substances may become poisons, and the means of discovering when they tend to that state IV. 349

Polatouch—vulgarly called the *Flying Squirrel*—its resemblances and differences with the Squirrel, Lori, and Rat—found alike in the northern parts of the old and new Continent—natural habits, &c. — III. 15, &c.

Pongo and *Jocko*—are the names given to the Orang Outang on the western coasts of Africa—resemble man most of the kind—the Pongo or great Orang Outang, is at least as great and much stronger—it always walks erect—constructs a hut, a shelter from the sun and rain—feeds on fruit and not on flesh — III. 433, &c.

Porcupine—not a Hog loaded with quills—its description and differences with the Hog—resemblances with the Beaver, has not the faculty of darting its quills as commonly thought—found commonly in Italy, particularly on the Apennine mountains—is neither ferocious or savage, extremely jealous of its liberty—its food in that state and in that of captivity, &c. III. 276

Pouch—kind of rat which is found in some countries of the north and which is larger than that of the domestic rat ——— IV. 90

Pregnancy—signs of ——— I. 62, &c.

Pu-

Puberty happens only when the body is attained the best part of its growth—the superabundance of nutriment is at this time perceived in the male and female—signs which precede and accompany it——throughout the human species, girls are at puberty sooner than the males——in the hotter climates of Asia, Africa and America, most girls are at Puberty at 10 and even at 9 years—the traits of the visage and figure of the body changes so greatly in the time of puberty that the same person might often be mistook I. 47, &c.

Polecat——nature and temperament—kills all birds before it eats them——attacks the Bee-hives and and obliges the Bees to quit them——natural habits——continually at war with rabbits——a single family of Polecats capable of destroying a whole warren—dogs will not eat their flesh by reason of it stinking smell—what contains the matter which gives that smell—an animal of temperate countries—dreads cold and is not found in the northern climates—the European Polecat appears to be of the same class as the stinkards of America, whose species are more numerous and the nature more exalted II. 209, &c.

Quadru-

more dense planets are nearer the sun, &c. V. 355, &c.

Poisons—manner in which animal and vegetable substances may become poisons, and the means of discovering when they tend to that state IV. 349

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Pouch—kind of rat which is found in some countries of the north and which is larger than that of the domestic rat ——— IV. 90

Pregnancy—signs of ——— I. 62, &c.

Pu-

Puberty happens only when the body is attained the beſt part of its growth—the ſuperabundance of nutriment is at this time perceived in the male and female—ſigns which precede and accompany it——throughout the human ſpecies, girls ar- at puberty ſooner than the males——in the hotter climates of Aſia, Africa and America, moſt girls are at Puberty at 10 and even at 9 years—the traits of the viſage and figure of the body changes ſo greatly in the time of puberty that the ſame perſon might often be miſtook I. 47, &c.

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Q

Quadrupedes — generally walk by moving the fore leg, and the hind leg drags nearly at the same time——the name of quadrupede supposes an animal of four feet: if it wants two feet like the Manati, it is not a quadrupede and an abuse of this general denomination when it is applied to these animals——real quadrupedes are the folipedous and the forked feet ———when we descend fissispedous class, we meet with ambiguous quadrumanes——quadrupedes who make use of their fore feet as hands must be distinguished from the rest—enumeration of animals to which the name of quadrupede agrees in all the rigour of its acceptation, and of those to which it does not wholly agree and which form an intermediate class between the quadrupede and quadrumane——there is in reality more than one fourth of animals to which the name of quadrupede disagrees, and more than one half to which it does not agree in all the extent of its acceptation III. 412, &c.

R

Racoon—short description of—its natural habits—— climbs trees very easily—a native of America—— though

though originally of hot climates fears not the cold—eats all it meets with—is of the nature of the Maki ——— II. 300, &c.

Rat——devastations made by those of the north called *Lemings*——natural habits of——produces many times in the year——eat each other when pressed by hunger——varieties in this species——the whole species with its varieties appears to be natural to the temperate climates of the old Continent —— the Rat belongs to the old Continent, and did not exist in the new when it was discovered ——— II. 223, &c.

Rat, Water—natural habits of——does not frequent fresh water—has the toes of the feet seperated, yet swims very easily—dogs hunt with a kind of fury—males and females seek after each other at the end of winter, &c. II. 248, &c.

Rein Deer——reason, physical, why the female has horns as well as the male—its description and comparison with the stag—its natural habits——is become a domestic animal among the Laplanders—great utility drawn from these animals——fastened to a sledge and draws it easily 30 leagues a day—manner in which they rear and conduct these animals—its food in winter and summer III. 193, &c.

Reproduction——different modes made use of by nature for reproduction — explanation of the reproduction of vegetables and animals, which reproduce without copulation, or by the seperation of their

their parts——nutriment and reproduction are both not only produced, by the same efficient cause, but also by the same material cause——matter which serves for the nutriment and the reproduction of animals and vegetables is the same — it is a productive and universal substance composed of organical molecules, always existing, always active, whose reunion produces organized bodies —— IV. 132, &c.

Respiration—experiment which seems to prove that animals might be raised, and perhaps even children during sometime without suffering them to respire — by preventing the foramen ovale to be shut, &c. —— I. 13, &c.

Rhinoceros——belongs to the old Continent and not found in the new——the species not numerous and confined only to the southern climates of Africa and Asia — next to the Elephant the most powerful quadrupede — its size and dimensions — its legs much shorter in proportion than the Elephant's——use of its horns——its upper lip moveable and terminated by an appendix——description of this animal — number and figure of its teeth — use of its long lip——its food and state of captivity — listens attentively to all noise——where found——its food in a free state——battles of the Rhinoceros with the Elephant imaginary——manner of hunting and killing them——has a good smell, excellent ear, but bad eyes —— III. 111, &c.

Rivers

Rivers in the ſinuoſities exactly follow the correſponding direction of mountains——when in a valley the inclination of one of the mountains which confines it is leſs rapid——in general rivers occupy the middle of valleys, or rather the loweſt part between two hills or mountains——of the change of beds in rivers——the ſurface of a river in motion is not level with both ſhores—enumeration of the number of ſtreams which fall into large rivers—in ſmall and large rivers the ſhores form angles alternatively oppoſite III. 132, &c.

Rouſſette and *Rougette*—two ſpecies approaching each other—reſemblances and differences—both belong to the hot climates of the old Continent—their reſemblances and differences with the Vampyre—carnivorous animals——manner of taking them by inebriation with fermented liquors——commonly go in troops, and more in the night than day——examination and deſcription of the tongue of the Rouſſette —— —— III. 9, &c.

S.

Sand—what is underſtood by the word——vitrifiable ſand and clay, which is only decompounded vitrifiable ſand, is the common matter of the globe, and all rocks whether of the vitrifiable or calcinable claſs are equally reſted on clay or

vitri-

vitrifiable sand——sand by decompounding produces flaky leaves, and by a still more complete decomposition becomes clay III. 360, &c.

Sai——a small species of the Sapajou——description, nature, nutriment, &c. – distinctive characters of this species — Ditto. 71, &c.

Saiga——an animal which forms an intermediate species between the Goat and Gazel——description and natural habits - III. 288

Saimiri—a small kind, and the most beautiful of Sapajous—description and natural habits——distinctive characters — IV. 72

Sajous——are less——two varieties, the brown and grey—description and nature—distinctive characters of this species ——— IV. 70

Saki——great species of the Sagoins——distinctive characters ——— IV. 24

Sapajous and *Sagoins* ——general and particular characters which divide the Sapajous and Sagoins from Monkeys, Baboons and Apes——the characters for this distinction——may be looked upon as their representatives in the new continent——resemblances and differences—eight kinds and their enumeration IV. 59, &c.

Sariga or *Apossum* — an animal of the new continent——two singular characters by which it is distinguished from all other animals—description of the female and the pouch under her belly——conformation of the parts of generation — the young conceal themselves in the

the pouch of their mother—move slowly III. 51

Savages——their thoughts of walking——description of the American savages——with reflections on their customs and manners—the American savages detest slavery, and had rather die than serve or work I. 256, &c.

Senses——one common principle——I. 157——must be looked upon as essential parts to the animal œconomy——internal and common sense affected by the means of the external, and how it produces and determines the motion of an animal——difference of the internal and external senses——degrees of excellence in the senses——Man has feeling, sight and hearing more perfect, but the smell more imperfect than an animal I. 304, &c.

Sensation——distinction between sensation and sentiment —— II. 156, &c.

Sensibility——natural——is perhaps more sure but always less strong than acquired II. 155

Sentiment—effect of——in animated beings——in what its essence consists — II. 153

Serval—name given by the Portuguese in India, to a wild and ferocious animal, larger than the wild cat and something smaller than the civet—description of, its nature, ferocity and nimbleness —— III. 333, &c.

Shrew Mouse—its nature, colour, &c. II. 241

Sight—case of one who was restored to I. 143

Sleep—the first state of an animal I. 247

Sorrow—its expression described - - I. 90

Souslik—a small quadrupede resembling the Mulot IV. 90, &c.

Species—human—varieties of, - I. 171

Sterility—causes of in men and women—the most common is the alteration of the seminal liquor in the female testicles and generally speaking sterility is most often from the fault of the woman than the man - I. 57, &c.

Strength—of man and animals compared—woman inferior in strength to man and therefore often tyrannically used - I. 76, &c.

Superfetation—example of in women—superfetations frequent in the Hare—and why I. 61, &c.

Surikat—the name of a pretty little animal found at Surinam, and in some other parts of South America—its description and nature III. 308

Sweden—women of—the Swedes long lives II. 25

Syagua—description of - - II. 418, &c.

T

Talapoin—small monkey—very pretty - IV. 8

Tamanoir—short description of—covers its whole body

body with its tail—singularity in the consistance of the coat of it---goes slow, and a man may easily overtake it---its strength and the manner in which it defends itself against animals of prey---not met with in Africa, although some authors have asserted so - III. 23, &c.

Tamarin——small kind of Saguin—distinctive character — - IV. 75

Tanrec or *Tendrac*——small animals of the East Indies resemble our hedgehog——two different kinds———the first thicker and larger and its snout longer than the second——nature and other properties of this animal III. 284, &c.

Tapeti——approaches the Hare and Rabbit——its description ——— IV. 102, &c.

Tarsier—the name given to a small ainimal like the Gubua—not larger than a rat—description and comparison with the Gubua — III. 310

Tartars——particular difference in them and particular observations —— I. 178

Tatuette—kind of Tatou with 8 streaks—its description and particular characters III. 41, &c.

Tatous—instead of hair are covered like the Tortoise, Crab and other crustaceous animals with a solid crust—several kinds of—generical characters and specific differences—belong to the new Continent —different names of different kinds—walk brisk but

but can neither run nor bound—natural habits —manner of taking them III. 50, &c.

Tayra—description of —— IV. 98

Theory of the Earth—turns on four principal circumstances—the strata, different beds, submerged, &c. V. 313, &c.

Tiger—generical name given to many different kinds of animals—the real, a very scarce animal—belongs to the old Continent—its size—characters which distinguish it from the Panther, Leopard, &c.—the Lion the first of carnivorous animals and the Tiger the second—nature and temperament—natural habits—never cloyed with blood—so strong that after having killed a Buffalo he drags it easily to the wood to feed on at his leisure—probably the only animal who nature will not bend—battle between a Tiger and three Elephants—use of its skin II. 381, &c.

Totai—a Rabbit with a long tail found in Tartary IV. 87

Touching or Feeling—the only sense which may be looked upon as necessary—explanation of its action—why the hand is the chief organ of it—this sense imperfect in animals who have not hands—the principal organ of feeling in animals is their snout —— I. 147, &c.

Tucan—description of —— IV. 100

V

Vampire——a flying quadrupede found in the hot countries of the new Continent——reaſon why named ſo—a different ſpecies from the Rouſſette or Rougette—its nature—how it can ſuck the blood of a perſon without waking him III. 9, &c.

Vanſire——name of an animal reſembling the Ferret—its deſcription —— III. 327

Vegetables——derive their nutriment more from air than water, &c. —— V. 440, &c.

Virginity——ſigns of, imaginary or very uncertain—ridiculous prejudice on this ſubject I. 48, &c.

Viſage——different forms of, in the different paſſions I. 73

Viſion—explanation of the manner in which it is done—demonſtration that we ſee objects reverſe and double although we ſuppoſe them otherwiſe I. 139, &c.

Viſon—character of —— III. 159

Voice—perſons with a falſe voice do not hear alike with both ears, this is the reaſon as ſuch perſons hear falſe—why the young falſe—acouſticons or hearing trumpets may be ſo inlarged as to increaſe ſounds — — I. 153, &c.

Volcano's

Volcano's—under the ſea—found in high mountains V. 317, &c

Voyage round the World—the firſt that made it was Magellan—Drake the ſecond, and Cavendiſh the third—the time each performed it in, &c. V. 416, &c.

U

Unan or *the Sloth*—deſcription of and compariſon with the Ai——theſe ſlothful animals the laſt term of exiſtence in the order of animals which have fleſh and blood——innate wretchedneſs of theſe animals—their food—ruminant animals——natural habits, &c. — III. 301, &c.

Univerſe—the ſyſtematic order is expoſed to all who would diſcover the truth—picture of it—millions of millions of luminous globes placed at an inconceivable diſtance, are the baſis which ſerve for the foundation to the edifice of the world—millions of apaque globes circulating round the firſt compoſe the moving order and architecture—two primitive powers agitate theſe enermous maſſes, turns them about, tranſports and animates them ——it is from the body of motion itſelf that the equilibrium of worlds and the quiet of the univerſe ſprings —— V. 353, &c.

Urſon——animal of North America——called the Por-

Porcupine of Hudſon's Bay—its figure, natural habits, &c. — II, 382, &c.

W

Wood—experiments on the ſtrength of—table of experiments—an eaſy mode to augment the ſolidity, ſtrength and duration of—experiments on the drying wood in air, and on its imbibition in water—experiment, to compare the time and gradation of dryneſs—table of the proportion of dryneſs—table of the imbibition of two pieces of wood when plunged into water—to diſcover the difference of the imbibition of wood, as the ſolidity is greater or leſs—on the imbibition of green wood—on the imbibition of dry wood both in ſalt and freſh water—table of theſe pieces — V. 224, &c.

Y

Yſquiepatl or *Stinkard*—is an animal the ſame as the Squaſh of New Spain — III. 354, &c.

Zecra

Z

Zebra—belongs to the old Continent—its description size, form, &c.—does not cohabit nor produce with the Ass or Horse——attempts to domesticate them and make them labour like horses—but hitherto not fully succeeded—nature in none of her works is so divided and so little connected as is the robe of the Zebra III. 175, &c.

Zebu—not the Babulus of the Ancients only a variety of the Ox—origin of this race III. 159

Zemni——description of——its nature and habits nearly like those of the Hamster and Zizel IV. 89, &c.

Zibet——its resemblances and differences with the Civet —— III. 429, &c.

Zizel——its resemblances and differences with the Hamster——description and natural habits IV. 88, &c.

END OF THE INDEX.

Directions